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CHEMICAL SECTION.

Special Meeting, held Tuesday, January 30, 1900.

WHAT IS PARIANITE?

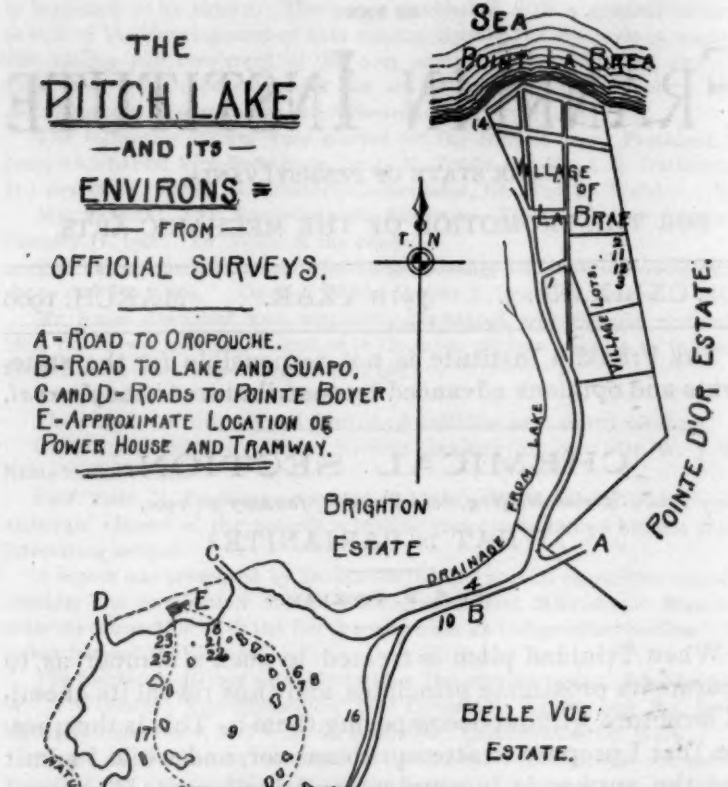
BY S. F. PECKHAM.

When Trinidad pitch is treated in such a manner as to separate its proximate principles, and thus reveal its chemical structure without decomposing them? This is the question that I propose to attempt to answer, and while I admit that the answer is incomplete and inadequate, I contend that I have entered a course of investigation that will ultimately lead to conclusions that will be final.

THE SPECIMENS.

The specimens used were those collected by myself in 1895. They were fully described in the paper published by myself with Miss Laura A. Linton, in the *Am. Jour. Science,* for March, 1896. The description of their location relative to each other and to the lake is thus given from that paper:

No. 1 was picked up at random from the pitch taken from an excavation from which the cargo of the bark "Ella" was dug, during February and March, 1895. The



excavation was upon a village lot about three-quarters of a mile from the lake towards Point La Brea.

No. 2 is from a village lot, which we have named the "Photograph Lot." It was here that a pit was dug and

photographs taken of the pit at intervals of ten days to determine whether any movement in the pitch was in progress by which a cavity dug in the pitch would refill. No. 2 was taken from the pitch removed from the pit. This lot had been excavated about six months previous and had nearly refilled, and was then being uncovered preparatory to the removal of a fresh supply of several thousand tons. The pit refilled 40 per cent. of its dimensions in ten days. It was about 20 rods nearer Point La Brea than No. 1.

No. 3 is so-called "Iron Pitch" from the Photograph Lot. This is pitch that has been melted and deprived of its water and gas. It is solid, of a bluish-black color, with a dull earthy fracture, and is slightly sonorous when struck.

No. 4 was taken from a lot on the right-hand side of the road approaching the lake, that was being excavated by Mr. Ghent. It came from a point 10 or 15 feet below the surface on the western border of the mass filling the ravine down which the overflow of pitch from the lake has taken place, and nearly on the opposite side of the road from the point from which No. 10 was taken.

No. 5 is No. 4, boiled to form Épureé, in Mr. Ghent's boiling works near Point La Brea.

Nos. 6 and 7 were from opposite corners of a mass about 12 inches square and 4 inches in thickness. This mass was taken from a point on the northeast side of the lake on the outside of and near to the tramway, and was selected of convenient size from among a quantity that had been broken with a pick preparatory to removal in the tram cars or carts by the Trinidad Asphalt Company.

No. 8 is from an average from the same piece made up by breaking fragments from many points upon its surface.

No. 9 is from the center of the lake or near it. The mass was soft enough to flatten in the shade, but did not stick to the paper in which it was wrapped. After drying, it became rigid and brittle.

No. 10 is an average from a large piece taken from an excavation being made by the Trinidad Asphalt Company

on the Bellevue Estate near the road leading to the lake. The excavation extended along the road for, perhaps, 1,500 feet, and was narrow. The pitch was clean and pure, but was covered by rank vegetation that grew upon and in the pitch itself, and not upon soil that covered it. This fact accounts for the high percentage of organic matter not bitumen, although the piece was taken several feet below the surface.

No. 11 is a decomposition product of the pitch from the Photograph Lot.

No. 12 is another decomposition product from the same lot. It resembled coke and may have been heated. It is the only material resembling coke that we saw in or around the lake and the amount was only a few pounds.

No. 13 is also a decomposition product resembling No. 11 from the south side of the lake. It was enclosed by a pellicle of sun-dried, melted pitch, within which it was of a light brown color with a columnar structure, like starch, and was very easily powdered.

No. 14 is from a pile of land pitch melting on the beach of Point La Brea, said to have come from the same lot as No. 1.

No. 15 was brought from the lake about 1865, by the late William Atwood, of Portland, Me.

No. 16 is from the southeast side of the lake inside the road, and was cut from the surface at a spot free from vegetation. The point was about halfway from the tramway to the border of the lake.

No. 17 is from the west side about midway of the tramway loop, where men were loading tram cars. It was picked up from under the feet of the men.

No. 18 is iron pitch, on the northeast side of the lake near where the left limb of the tramway, looking south, enters upon the lake.

No. 19 is refined land pitch, from the refinery of the Trinidad Bituminous Asphalt Company, at Jersey City, N. J. It came from the same lot as No. 2.

No. 20 is refined lake pitch, purchased in New York of the Warren-Scharf Company.

No. 21 is from the northeast side of the lake near the left limb of the tramway looking south.

No. 22 is from the northeast side of the lake near the right of the left limb of the tramway loop looking south, about 100 feet from No. 21.

No. 23 is from the northwest side of the lake on the west side of the right limb of the tramway loop looking south.

No. 24 is from the south side of the lake near where the road leaves the lake.

No. 25 is from the northwest side of the lake on the west side of right loop of the tramway looking south near a "blow hole."

No. 26 is from the south side of the lake near where the road leaves it, about 100 feet from No. 24.

No. 27 is Épureé from the boiling works of the Trinidad Asphalt Company, at Point La Brea. It was made by boiling a mixture of Nos. 10, 8 and 9.

Nos. 6, 7, 8, 9 and 17 represent commercial lake pitch.

Nos. 16, 21, 22, 23, 24, 25 and 26 represent the contents of the lake occupying the annular space outside the tramway and embracing hundreds of thousands of tons.

Nos. 1, 2, 4, 10 and 14 represent an average of commercial land pitch.

Nos. 5 and 19 represent refined land pitch.

Nos. 20 and 27 represent refined lake pitch.

Nos. 3, 11, 12, 13 and 18 are rubbish as far as commerce is concerned, and are introduced here to show that there is rubbish in the lake as well as outside of it, and also the relation of alteration products to the commercial pitch. The locations of the several specimens are shown on the accompanying map.

It will be seen that these specimens consisted of five each of commercial lake and land pitch, seven from the annular space between the tramway and the circumference of the lake, a specimen each of iron and chocolate pitch from both the lake and the land, a specimen resembling coke, a specimen of refined lake and land pitch, two specimens of Épureé, and a specimen brought from the lake by William Atwood about 1865.

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THE METHOD OF ANALYSIS.

As is the case with all other methods of chemical investigation, the investigation of bitumens, as at present conducted, represents a growth. The starting-point is the classical research of Boussingault, first described in 1837. (*Ann. de Chem. et de Phys.* (2), LXIV, 141.)

It must be remembered that this research was undertaken more than sixty years ago, when organic chemistry was in its infancy as compared with to-day, and when the methods of investigation with which the chemists of to-day are familiar were unknown. It detracts nothing from the value of Boussingault's work to say that it is worthless as a guide in modern research.

I have found by years of experience that solid bitumens cannot be investigated by ordinary methods of distillation. Trinidad pitch, either lake or land, is decomposed when heated to a temperature of 100° C. with a copious evolution of hydrogen sulphide. Whether or not this reaction would attend distillation in vacuo I do not know.

The methods of analysis by solution remain. Why should objection be made to them? Why are they not analytical? I really do not know. Solution may certainly be properly considered a chemical reaction, and the more solvents that can be applied to a solid with clearly-defined results that can be repeated with accuracy, the more complete must be the method of analysis. To dissolve a bitumen in carbon disulphide, which is a universal solvent for bitumens, does not analyze the bitumen, although it may separate the bitumen from its impurities; but to subject a bitumen to the action of several solvents in succession, by which the bitumen can be referred to a distinct class, is a valuable analytical process.

These considerations have been impressed upon my mind during the several years last past, in which I have been attempting to arrange a process of analysis that shall apply to all bitumens, and enable the analyst to distinguish, both alone and in mixtures, the several varieties of bitumen, in a manner similar to the schemes that have been proposed for alkaloids or other organic compounds.

Parianite may be regarded either as an emulsion of gas, mineral water; bitumen, that is, compounds of carbon, hydrogen and nitrogen, oxygen and sulphur, any or all of the last three, with organic matter not bitumen, and mineral matter consisting of silica and clay as impurities; or, it may be regarded as an emulsion of gas, water holding mineral salts in solution, bitumen as above described, with complex organic salts of iron, alumina, lime and magnesia, with ulmic and, perhaps, other peat acids, with ferrous sulphide, and silica, some portions of which are in combination with the other ingredients and the remainder free. Either alternative exhibits a very complex substance, but each quite unlike the other. By what means can it be determined of what the mixture really consists? Certainly not by any process that separates a hypothetical substance called petrolene and a second called asphaltene, a third called organic matter not bitumen, and a fourth called mineral matter. One might just as well *analyze* a log of wood by burning it into smoke, flame and ashes.

THE GAS.

We will begin at the lake with the gas. I visited the lake on Point La Brea on four different days, and practically walked all over the deposit, both inside and outside the lake. I did not once recognize the odor of hydrogen sulphide. When I was in California in 1865, it was stated that the big spring on the upper Ojai plateau discharged carburetted hydrogen. I found the gas would not burn, and then I gathered some of it and found it was nearly pure (carbonic acid) carbon dioxide. I suspect that the greater part of the gas discharged from the lake is also carbon dioxide. It is the normal product of the deoxidation of the sulphates contained in the lake water, as sulphuric oxide yields more oxygen than is sufficient to convert the bases present into carbonates. No doubt the deoxidation of the sulphates in the water is attended with a variety of reactions resulting in a variety of chemical products, of which both carbon dioxide and hydrogen sulphide form a part. The proper place to investigate these gases is at the lake.

THE LAKE WATER.

Mr. Richardson has fully investigated the lake water, and in his report of 1892 he gives his results in great detail. The water used by him was taken from the water floating on a kettle of melted pitch that was being refined. It was probably more highly concentrated than lake water, and had, perhaps, lost some of its volatile ingredients. He gives the following analytical results:

IN 1 KILOGRAM.

	Grams.
Cl	6·7757
SO_3	5·5409
SO_2	·0467
S_2O_7	trace
H_2S	"
S	"
SiO_2	·0688
B_2O_3	·0117
I	·0008
Br	trace
P_2O_5	none
Na	6·5149
NH_4	·4071
K	·3391
Li	·0271
Ca	·5280
Mg	·2666
Fe	·0720
Al	trace
Mn	none
Cs&Rb	"
Organic	·4901
Oxygen	none
	21·0896

It is probable that these results *indicate* but do not represent the composition of lake water. They also *indicate* the composition of the water saturating the pitch. This water, examined by Mr. Richardson, has an acid reaction.

In the paper recently published by Mr. Richardson (*Jour. Soc. of Chem. Industry*, January, 1898), he gives an analysis of water from a spring that arose in the pitch:

IN 1 KILOGRAM.

	Grams.
Specific gravity	1·0599
Solids at 110° C.	82·100
Sodium, Na	27·193
Potassium, K	0·528
Chlorine, Cl	38·210
Sulphuric acid, SO_3	3·207
Calcium oxide, CaO	trace
Magnesium oxide	0·506
Carbonic acid, CO_2	3·700
Silica, SiO_2	0·222
Organic matter	?
	73·566

From these analyses it appears that the lake water is rich in chlorides and sulphates of sodium and iron, with iodides, bromides and borates, in the first instance, and carbonates in the second.

AQUEOUS SOLUTION OF THE PITCH.

One hundred grams of No. 8, which is a fine specimen of commercial lake pitch, were digested with successive portions of distilled water at a temperature of 60° to 70° C., until there was no longer a reaction for either Cl or SO_3. The first portion contained a large amount of ferrous sulphate. The solution, on standing, deposited a small amount of ferric oxide. The solutions were concentrated to 1 liter and portions of 100 cubic centimeters were evaporated over a water-bath. The residue contained chloride and sulphate of iron and sodium. Probably a larger portion would give reactions for all the soluble salts obtained by Mr. Richardson from lake water. This residue also contained a small amount of organic matter that was not determined. The percentage of this residue was 1·135 per cent. of the pitch.

THE ALKALINE SOLUTION.

It is impossible to visit the pitch lake without observing that an immense amount of partially decayed vegetation is entombed in the pitch. Enormous stumps are uncovered, with trunks and branches of trees in every stage

of decay, from solid wood to large masses of humus that a kick will scatter, precisely as if they were found in the peat of a bog. This humus becomes kneaded and incorporated with the pitch precisely as is the mineral matter, and, what has not been properly recognized, the humus on a colossal scale has formed those peculiar compounds, the precise natures of which are but little known, but which Mulder, Boussingault and others have referred to amides and double salts, in which ammonia, the peat acids and iron, and especially alumina, are combined into exceedingly complex compounds, insoluble in water, but readily yielding to solutions of alkaline hydrates and carbonates. These reactions are brought together from many researches and admirably treated by Prof. S. W. Johnson in his "How Crops Feed," pp. 276–280, to which the reader is referred. The treatment there recommended to be applied to soils for the determination of the humus compounds has been applied to this sample of Trinidad pitch with the most satisfactory results, and a flood of light is thrown upon the problems presented by these unique and complex substances. 4·9325 grams of the dried residue, which represent 5·000 grams of air-dried pitch, were digested in successive portions of a solution of dry sodium carbonate, 5·3 grams to 1 liter of distilled water. The first portion was colored as dark as port wine and the last portion was uncolored. The alkaline solution was acidulated with hydrochloric acid and the precipitated ulmic acid was collected on a balanced filter, dried at 100° C. and weighed. The ulmic acid represented 1·542 per cent. of the pitch. The residue from the sodium carbonate solution was then boiled with a dilute solution of sodium hydrate and the dissolved ulmin was precipitated with hydrochloric acid in considerable amount.

The acid solutions were neutralized with sodium hydrate, acidulated with acetic acid and the apocrenic acid precipitated with acetate of copper. Only a trace of crenic acid was precipitated by ammonia. This might reasonably be expected, as crenic acid is being continually converted to apocrenic acid by contact with reducing sub-

stances, of which bitumen is a notable instance. I am inclined to think that Prof. S. W. Johnson's observation, that ulmin represents only the ulmic acid of difficultly decomposable ulmates, is correct ("How Crops Feed," p. 225, note). It is well known that ulmic acid and ulmin have the same composition, but the first is readily soluble in Na_2CO_3, while the latter requires prolonged boiling with NaHO for its solution. I believe that the ulmin represents only the ulmic acid that is in combination with alumina and iron, which compounds are decomposed with considerable difficulty.

Wiley, in his "Principles and Practice of Agricultural Analysis," Vol. I, p. 28, recommends for the determination of humic and ulmic acids the use of the Huston-Grandeau method, as follows: 10 grams of the soil are washed with a 3 per cent. solution of HCl, and then washed into a 500 c.c. cylinder with a 4 per cent. solution of ammonium hydrate. Shake and let remain in a horizontal position for thirty-six hours. Determine the humus in an aliquot part. This is, no doubt, a very good method for ordinary soils containing free peat acids and their salts of lime and magnesia; but, used on No. 8, the amount of ulmic acid obtained was only 0·044 per cent. against 1·542 per cent. obtained by the sodium carbonate method. In parianite the peat acids are, no doubt, combined with iron and alumina, as only traces of lime and magnesia were found in the HCl solution.

The ammonia that has been observed escaping from kettles of melted pitch when it is refined is, without doubt, derived from the amido compounds referred to above. The relation which the pitch bears to a soil is strikingly shown in the luxuriant vegetation that covers the pitch wherever it is not in motion. Outside the lake a tropical jungle grows, with its roots penetrating the pitch and forming a sod of great tenacity, which often renders tons of the pitch worthless from admixture of vegetable matter. Such pitch is universally rejected.

THE DETERMINATION OF WATER.

The pitch is taken from the lake dripping wet. It begins to dry out immediately, but it requires a long time to completely remove the water if the lumps are unbroken. It is, however, easily dried if pulverized and placed in the sun. By thus drying to a constant weight the water may be determined.

Another method that I have found very convenient for determining water in semi-fluid or solid bitumens is to dissolve the bitumen in refined and recently distilled illuminating oil and distil in an alembic or tubulated flask, collecting the distillate in a graduated cylinder and measuring the water, which may be estimated to weigh a gram to a cubic centimeter at 60° F. For this purpose, at least 50 grams of the bitumen should be dissolved in 200 cubic centimeters of the liquid, and the distillation should be continued until no more water passes over.

PETROLEUM ETHER SOLUTION.

For this determination three washed filters should be balanced. Into two of them should be weighed 1 gram of the pitch. These filters should be placed in separatory funnels and exhausted with dry petroleum ether, of 74° B. or higher, as rapidly as possible. The percentage of dry pitch dissolved by the petroleum ether will vary within narrow limits from 32 to 36 per cent.

Of those analyzed by Miss Linton, Nos. 6, 7, 8, 9 and 17 were commercial lake pitch. They contained the following named amounts of petroleum ether solubles:

	Petroleum Ether.	Mineral Matter.	Total Bitumen.		To Mineral Matter.
No. 6	36·650	35·337	1	:	·656
" 7	36·372	35·975	1	:	·671
" 8	36·475	35·712	1	:	·657
" 9	35·950	35·192	1	:	·651
" 17	34·200	35·645	1	:	·672
Average . .	35·929	35·572	1	:	·661

Nos. 21, 22, 23, 24, 25, 26 and 16 were from the annular

space between the tramway and the edge of the lake. They were all specimens of good, clean cheese pitch.

	Petroleum Ether.	Mineral Matter.	Total Bitumen.		To Mineral Matter.
No. 21	26·925	36·537	1	:	·699
" 22	34·725	36·310	1	:	·688
" 23	34·412	35·612	1	:	·672
" 24	33·187	36·175	1	:	·686
" 25	34·900	38·462	1	:	·754
" 26	35·362	38·762	1	:	·774
" 16	35·400	36·100	1	:	·681
Average	33·558	36·851	1	:	·707

Nos. 1, 2, 4, 10 and 14 are samples of clean commercial pitch, from points outside the lake.

	Petroleum Ether.	Mineral Matter.	Total Bitumen.		To Mineral Matter.
No. 1	33·617	37·462	1	:	·737
" 2	33·620	36·201	1	:	·692
" 4	33·736	36·729	1	:	·701
" 10	33·730	35·886	1	:	·682
" 14	31·775	37·460	1	:	·743
Average	33·295	36·747	1	:	·711

Placing the averages together they give:

	Petroleum Ether.	Mineral Matter.	Total Bitumen.		To Mineral Matter.
C. Lake	35·929	35·572	1	:	·661
Annular Lake,	33·558	36·851	1	:	·707
C. Land	33·295	36·747	1	:	·711

Mr. Richardson raises the average in the annular space to 35·2 by throwing out No. 21, which he had no right to do, as No. 21 was a specimen of clean cheese pitch from inside the lake, and some distance beneath the surface. There is no better reason for throwing it out than for throwing out No. 17 from the lake pitches.

The annular space from which the seven specimens above enumerated came represents 80 per cent. of the surface of the lake and probably 70 per cent. of the entire mass. This 70 per cent. is constantly moving towards the center of the lake as the pitch is removed along the tramway.

Taking the specimens on the line of outflow from No. 17 to No. 2, we have:

	Petroleum Ether.	Mineral Matter.
No. 17	34·200	35·645
" 9	35·950	35·192
" 6	36·650	35·337
" 7	36·372	35·975
" 8	36·372	35·712
" 16	35·400	36·100
" 10	33·730	35·886
" 4	33·736	36·729
" 2	33·620	36·201
" 1	33·617	37·462

Showing conclusively that, with slight variations, the mineral matter increases from No. 9 at the center of the lake to the village lots, Nos. 1 and 2, nearest the sea.

The petroleum ether soluble in my five specimens of commercial lake pitch is on an average 1·186 per cent. above that of the twelve lake specimens. The seven specimens that represent 70 per cent. of the mass in the lake are 0·264 per cent. above the five specimens that were all clean commercial land pitch. It will also be observed that the ratio of total bitumen to mineral matter increases in the averages given from 1 : ·661 in the five lake specimens to 1 : ·711 in the five land specimens. Of course, if the mineral matter increases, the other ingredients must diminish. These differences are so slight that really it is very wonderful that a mass of material of such vast magnitude should present such striking uniformity of composition.

So far as it is possible to use Mr. Richardson's results in a similar manner, they show the same inverse proportion between the amount of petroleum ether soluble and mineral matter as the specimens are taken from points removed from the center of the lake.

If the petroleum ether solution be allowed to stand, it deposits a film upon the surface of the containing vessel beneath the liquid. This deposit is not a precipitate. If the vessel is of glass, the entire surface of the glass beneath the liquid is covered with the film, from which the liquid may be cleanly poured. This film readily dissolves in chloroform to a transparent solution. This chloroform solution evaporated to dryness over a water-bath gave 1·884 per cent.

of the pitch, of a brilliant black solid, which, when heated, melted, distilled, intumesced and burned to a very porous light ash that appeared to be alumina. The ash amounted to 41·508 per cent. of the solid mass or 0·0782 per cent. of the pitch.

If the petroleum ether soluble be treated in solution with fuming nitric acid an orange-colored nitro derivative is obtained, from which the petroleum ether may be easily distilled. An examination of these nitro derivatives is a much more promising field for research than the products of distillation, contaminated as they are with the inevitable decomposition products of high temperatures.

THE TURPENTINE SOLUTION.

When in California, in 1894, I treated 100 grams of lake pitch with boiling spirits of turpentine, and upon adding to the solution a large excess of petroleum ether, obtained a copious brown precipitate. I gathered this precipitate on a filter and washed it with petroleum ether, in which it is wholly insoluble. It is also insoluble in ethyl ether and ethyl and methyl alcohol. Heated in a platinum crucible, it yields a large percentage of ash. This ash consisted of:

Silica	—
Alumina	—
Iron	—

For a long time I supposed this precipitate was asphaltene, but on attempting to determine the sulphur in it I found it was an organic compound of silica and alumina. I have not yet completed my investigation of this material, which I believe is a double salt of alumina, containing ulmic acid.

More than 12 per cent. of the precipitate may be dissolved in solution of sodium carbonate and a still larger percentage may be dissolved in solution of sodium hydrate, from both of which solutions hydrochloric acid will precipitate an organic acid. This material also furnishes a much more inviting field for research than the decomposition products of distillation. Dr. Endemann isolated from the residue that he obtained by his peculiar process a substance

that he called asphalt-ulmic acid. It is, no doubt, ulmic acid that had survived the fiery ordeal through which his residue had been made to pass, and was one of the few constituents of the original parianite that had escaped decomposition.

THE CHLOROFORM SOLUBLE.

When the residue left on the filter from treatment with boiling spirits of turpentine is treated with cold chloroform, a third portion is dissolved. The percentage varies with the pitch. In those analyzed by Miss Linton it varied in the five land pitches from 3·139 to 8·185, in the lake pitches from 2·137 to 7·222, and in those from the annular space from 4·800 to 6·990. In the rubbish it varied from 1·300 to 15·112. The average of the

	Per Cent.
Five land pitches	6·504
Five lake pitches	5·012
Seven annular pitches	5·604
Five rubbish	10·334

The two Épureés were 2·675 per cent. and 9·187 per cent. The two refined pitches were 6·002 per cent. and 6·297 per cent.

When the soluble is evaporated from the chloroform it forms a brilliant, black, hard varnish. Heated, the varnish melts, intumesces, gives off heavy vapors which burn with a smoky flame, leaving a red ash, consisting chiefly, if not wholly, of ferric oxide. In one instance a portion of this varnish yielded 0·779 per cent. of this ferruginous ash.

This soluble is precipitated from its solution in benzole or chloroform upon the addition of an excess of petroleum ether, as a seal-brown powder. This precipitate may be washed with petroleum ether, ethyl alcohol or ether, in all of which it is insoluble. Analyses, that have been fully described elsewhere, and for which no claim for absolute accuracy is made, have shown this precipitate to consist of an organic sulpho-salt of iron (*Jour. Soc. Chem. Ind.*, December, 1897, No. 12, Vol. XVI). Here is also a more profitable field for research than is found among the decomposition products of distillation.

THE HYDROCHLORIC ACID SOLUTION.

Whenever limestone forms any part of a bituminous mixture, whether natural or artificial, it is essential that it should be determined. When crushed stone is used, some portion of it is usually soluble in hydrochloric acid. Gypsum is also dissolved by it, and may be detected by testing the solution for sulphuric acid. A very small percentage of the residue of parianite after chloroform is soluble in a 10 per cent. solution of hydrochloric acid. I have not ascertained what elements enter this solution.

THE RESIDUE.

That which remains on the filter after treatment with hydrochloric acid consists of cellulose and humus, mixed with such mineral matter as is not in organic combination in the pitch. The organic matter cannot be burned off without decomposing pyrite and burning out more or less of the sulphur, as the ash of the filter is usually saturated with ferric oxide in the form of colcotha. The proper procedure is to cut the filter in small pieces, mix these pieces with sodium carbonate and potassium nitrate and deflagrate. The silica, iron and alumina can then be determined while the sulphur appears as sulphuric acid, in the usual way. By determining the sulphur in another portion of the pitch in like manner and deducting the sulphur found in the residue from the whole amount of sulphur, the sulphur in organic combination can be ascertained. At the same time that this total amount of sulphur is determined, the total amounts of silica, alumina and iron can also be correctly determined. This correct total amount of mineral matter will be found to be considerably in excess of the amount found by the usual method of analysis by solvents; inasmuch as an appreciable amount of alumina and iron in combination with organic radicals pass into solution, which exist in the pitch dissolved in the bitumen, and which in the process of analysis pass into the solutions formed by the various solvents employed.

In the remarks made by Mr. Clifford Richardson, at the

time the paper was read, of which myself and my son were joint authors (*Jour. Soc. Chem. Ind.*, May 31, 1897), he was made to observe (I quote from memory) "that the percentages given were percentages of the ash. Adding together the 19 and 21 made 32. The silica and oxide of iron made up the total." In this he was mistaken. The percentages given, 19·182 per cent. and 21·168, amount to 40·350. In the ordinary method of analysis by solvents, with combustion of "organic matter not bitumen" and determination of the residue from the combustion, the organic matter not bitumen amounted to 8·507 per cent. and the mineral matter to 32·243 per cent. How large a part of the organic matter not bitumen was sulphur cannot be conjectured; but no question can be entertained for a moment that a very considerable portion of the 3·639 per cent. of sulphur is lost in that way. Whatever the amount may be, the total per cent. of material that is not bitumen, obtained by solution, is 40·750, while the sulphur, silica, alumina and iron, by the direct method amounts to 43·989 per cent. 19 and 21 make 40, instead of 32, as Mr. Richardson suggested.

In the paper lately published by Mr. Richardson (*Jour. Soc. Chem. Ind.*, January 31, 1898), and which I have elsewhere noticed (*Jour. Soc. Chem. Ind.*, November 30, 1898, p. 1003), he draws some very extraordinary conclusions, which he states as follows: "The additional determinations of bitumen made by Professor Peckham with chloroform also furnished some additional and conclusive evidence of the difference between the two kinds of material (pitch from within and without the lake). These show that the average land specimen contains 2·4 per cent. more of its bitumen in this difficultly soluble form, while iron pitch, which is acknowledged to be of no value for paving purposes and is always rejected in digging land pitch, has 7·3 per cent. more of its bitumen in this form. From this we can draw the inference that the land pitch collected by Professor Peckham is one-third converted into iron pitch, and of so much less value than lake pitch for paving purposes. In fact, his results are conclusive evidence of the differences between lake and land pitch as any that have been offered, and con-

firm the result of experience with the asphalt from the land deposit in the laying of street pavements."

This remarkable paragraph, in the first place, is incorrect in its arithmetic; in the second place, in assuming any relation between commercial pitch, either lake or land, and iron pitch, hence in assuming that any ratio exists between lake and iron pitch. Using Mr. Richardson's figures, the chloroform soluble of the average lake specimens is 9·848 per cent. of the total bitumen in those specimens. In the land specimens the chloroform soluble is 12·572 per cent. of the total bitumen. In the single iron pitch selected by him (3) the chloroform soluble is 17·308 per cent. of the total bitumen. The differences are 2·724 and 7·460 per cent. The average chloroform soluble in the five commercial lake specimens, 6, 7, 8, 9 and 17, correctly determined, is 9·331 per cent. of the total bitumen. In the seven specimens in the annular space between the tramway and the circumference of the lake, Nos. 21, 22, 23, 24, 25, 26 and 16, the chloroform soluble averages 10·771 per cent. of the total bitumen. In the five commercial land pitches, Nos. 1, 2, 4, 10 and 14, the chloroform soluble averages 12·569 per cent. The chloroform soluble in the iron pitches, Nos. 3 and 18, averages 22·709 per cent. of the total bitumen. Arranged in order with differences according to Mr. Richardson's argument, they are:

Lake	9·331		
Annular	10·771	difference	1·440
Land	12·569	"	3·238
Iron	22·709	"	13·378

According to Mr. Richardson's argument, the pitch in the annular space is one-sixth converted into iron pitch and the land pitch is one-fourth converted into iron pitch. Keeping on with the argument, the lowest ratio of chloroform soluble to total bitumen in any of the specimens examined by Miss Linton is in No. 8. In this specimen the chloroform soluble is 3·932 per cent. of the total bitumen. This specimen came from outside the tramway. In No. 9, from the center of the lake, the chloroform soluble is 10·668;

that is, the pitch at the center of the lake is nearly three times nearer iron pitch than that outside the tramway. In No. 17, just outside the tramway on the southwest side, the chloroform soluble is 13·648, or four times nearer iron pitch than No. 8 on the northeast side. Or, according to this argument, assuming, as we have a right to, that pure pitch has no chloroform soluble, that the pitch at the center of the lake is one-half converted into iron pitch. The fact of the case is, however, that iron pitch is not a decomposition product, nor is the chloroform soluble an effect of decomposition, although the accumulation of this ingredient of the pitch in large amount may apparently result from the decomposition and partial removal of the other constituents. Nos. 11 and 13 are so-called "chocolate pitch." The material is plainly the result of a sort of partial decay of the pitch. The average percentage of petroleum ether soluble in these two specimens is only 38·980 per cent. of the total bitumen, while the chloroform soluble is 26·824 per cent. of the same. Chocolate pitch is found in very small quantity in the deposit wherever the conditions are favorable to its production, but it is not a commercial product. Iron pitch has been formed by the melting and partial distillation of the pitch from jungle fires, and is so uniformly rejected from the commercial pitch that it is almost impossible to find a piece of appreciable size in a cargo of crude pitch.

THE ORGANIC MATTER NOT BITUMEN.

In the seventeen specimens of crude pitch, taken from as many different points, both within and without the lake, the so-called organic matter not bitumen was found to be on an average 11·074 per cent. of the pitch. Precisely of what this consists has not been determined. It is obtained by burning the residue that remains from the solution in chloroform, at a dull red heat. If the pitch is not finely pulverized, but is treated in coarse lumps, the residue from the chloroform contains fragments of vegetation of appreciable size. There is also a considerable amount of an exceedingly fine gray powder that is easily recognized as

ferrous sulphide. A determination of the sulphur in this residue gave 0·8844 per cent. of the pitch; this is equivalent to 9·793 per cent. of the residue, or, 18·368 per cent. of the residue of ferrous sulphide. These figures are suggestive rather than final.

THE MINERAL MATTER.

This is the residue left in the crucible after the organic matter not bitumen has been burned off. It consists of grains of silica with a small amount of alumina and a much larger proportion of ferric oxide in the form of colcotha, which indicates that it is a product of decomposition, and that, too, of a substance that is very intimately mingled with the entire mass of the residue and even the fiber of the paper. The paper is as completely filled with anhydrous ferric oxide as if it had been previously soaked in a saturated solution of ferrous sulphate.

The average totals of this mineral matter in the seventeen specimens of normal crude pitch is 36·444 per cent. If, however, the mineral matter, that is, the silica, alumina and sulphur, are directly determined, they will amount to:

	Per Cent.
Silica	19·593
Iron and alumina	20·272
Sulphur	3·505
Total	43·370
By solution	36·444
Difference	6·926

This difference of nearly 7 per cent. is certainly represented by constituents of the pitch, a part of which pass into solution in the solvents of the pitch and a part of which are volatilized as "organic matter not bitumen."

I am satisfied to frankly admit that at present we know very little concerning the composition of parianite, and further, to state my belief that nothing of any material value will be added to our present scant information until it is investigated rationally instead of empirically. This is a work of a lifetime.

ANN ARBOR, MICH., June 1, 1898.

Discussion.

Dr. H. Endemann:—I shall confine my remarks mainly to the methods of analyzing asphalts. There are at present two methods in use:

(1) Examination of asphalt by the successive use of solvents.

(2) The analysis of asphalt based upon the volatility of some constituents and the determination of the elementary composition of the non-volatile portion.

Prof. S. F. Peckham, following the lead of C. Richardson, is the representative of the first method, while I have devised the latter.

In my papers on asphalt, published in the *Journal of the Society of Chemical Industry*, during the years 1897 to 1899, I have shown, by qualitative tests and quantitative determinations, that the analysis of asphalt attained by the successive use of solvents is not an analysis at all, according to the standpoint of the chemist.

To divide a mixture into fractions each of which contains all the elements of the original mixture is not an analysis.

My results show that the fractions obtained by this method of examination are mixtures of all the constituents in asphalt in varying proportions.

The fraction obtained with petroleum ether contains the bulk of the volatile and stable hydrocarbons, but it contains twice as much of non-volatile hydrocarbons and organic substance containing oxygen. The residue is the same, only that it contains less of the volatile hydrocarbons. If this residue is treated, as proposed, by spirits of turpentine, this solvent will remove the last of the volatile hydrocarbons, together with a corresponding quantity of the non-volatile portion. The proportion of the latter which goes into solution depends entirely upon the amount of the volatile portion left in the residue from the first treatment. If no volatile hydrocarbons have been removed from an asphalt, the whole of the bitumen is soluble in spirits of turpentine.

The following is a short history of asphalt analysis.

The first to investigate asphaltum was Boussingault. He made an elementary analysis of the asphalt of Pechelberon and found that it contained aside of carbon, hydrogen, sulphur and nitrogen, about 2½ per cent. of oxygen. He then subjected it to distillation, when he obtained an oil of the approximate composition $C_{10}H_{16}$, and a very much larger quantity of a solid residue containing 15 per cent. of oxygen. The oil, which is really a mixture of hydrocarbons, he called petrolene and the latter asphaltene. That the latter product must be a product of a process of oxidation is evident. Say that he obtained 60 per cent. of asphaltene with 15 per cent. oxygen, the original asphalt should have contained 9 per cent. of oxygen in the place of 2½ found. This proves the process of oxidation without doubt.

Boussingault did not pursue the subject.

At the meeting of the American Chemical Society, held in Washington during the summer of 1892, C. Richardson read a paper on "Trinidad Asphalt," where he first introduced the method of examination by successive use of solvents, and introduced it as a simplification of the discredited Boussingault method, claiming that the petroleum ether extract was practically the same as the petrolene of Boussingault; hence he called this extract petrolene. It occurred to me, then, that Richardson's claim that the analysis was a simplification of Boussingault's, and practically alike in effect, was at least very doubtful. I did at that time not discuss his paper for the reason that I desired confirmation of my suspicions by practical experiment.

Whether he really tried to identify the petroleum ether extract with Boussingault's petrolene is doubtful. Certain it is that he used the name petrolene for his petroleum ether extract, and it is likewise certain that if he had earnestly tried to compare the two, he should have observed that only one-third of the petroleum ether extract consists of volatile hydrocarbons or Boussingault's petrolene, while two-thirds are fixed bodies.

Of reasons which caused me to look with suspicion upon the new method, I mentioned, for instance, logwood extract.

The poorer brands of the liquid extract are perfectly clear syrupy liquors, which, when dropped into water, separate into a water-soluble part and a muddy precipitate. The latter, when brought upon filter, is found to be insoluble in water.

But asphalt is a similar substance. I have in this bottle a solution of asphalt in petroleum ether, and in the second bottle pure petroleum ether, same as was used for the preparation of the extract. I now pour some of the solution into petroleum ether, and you can now see already that the solution becomes turbid, and at the end of the hour you will observe a precipitate covering the bottom of this four-ounce bottle with a layer of precipitate about $\frac{1}{10}$ inch in thickness.

These examples show that the solubility of one substance in another is, to a great extent, governed by the presence of a third substance and the concentration.

Prudence prescribes that in preparing a method the possibilities of such interference are considered and determined.

In the case of this method these precautions have been neglected entirely.

The reasons that I had not accepted the method by solvents are based upon the following experiments:

I took the petroleum ether extract left after the evaporation of the petroleum ether and heated it for a short time to a temperature near the one used in refining. I found that I could drive off in two hours one-third of its weight. The residue, or two-thirds of the extract, was a solid, but could then again be divided in a petroleum ether soluble and insoluble fraction.

There was in this process no actual distillation, but simply evaporation much below the boiling point of the volatilized substances. There was no flame, smoke or ashes in this process, as Mr. Peckham desires to imply.

As further steps I ascertained that, if this evaporation in air is prolonged, it is accompanied by dehydrogenation and oxidation by addition of oxygen, and also that such changes may be obviated if the evaporation of the stable volatile hydrocarbons is effected in a current of an inert gas,

for which I selected, for convenience, carbon dioxide. These points were elicited by a series of elementary analyses.

The line of investigation partly outlined here and followed up step by step landed me on the following facts:

Asphalt consists:

(1) Of a solid body, non-volatile, or, if volatile, at a very high temperature only, which forms the body of the asphalt and is the predominant constituent.

This solid body is in some asphalts a hydrocarbon, with less hydrogen than any of the petrolene hydrocarbons. Its composition corresponds to the formula $C_{20}H_{38}$. Isomers of this I have so far not found. It has been found in liquid asphalts.

Higher oxidized and hard asphalts may contain this, but they are characterized by the presence of an oxygen compound or oxygen compounds.

My first investigations led me to a formula $C_{25}H_{36}O_2$, but lately, with new asphalts, I have been led to a formula $C_{20}H_{24}O_2$. The first contains 8·5 per cent. oxygen; the latter, 10·5 per cent. oxygen; both oxidize alike when heated in a current of air to about 200°–250° C., the first yielding a compound with 15½ per cent. oxygen; the latter, one with 23 per cent. oxygen. (Asphaltic acid or oxide.)

Other homologues I have so far not found.

(2) Volatile hydrocarbons, mostly liquid, which are present in smaller quantity and which have been called "petrolenes."

The substances under 1 are solids which are softened by those under 2 in the same way as 80 rosin and 20 spirits of turpentine make 100 turpentine.

I have further shown that asphaltic acids dissolve in caustic soda under absorption of oxygen, forming asphaltulmic acid. It is not in asphalt, or certainly is not contained in the bitumen; it was simply prepared by me in the hope of settling the nature of the products from which it is derived. I also desire to say that in my opinion the ulmic acid obtained by Peckham from Trinidad pitch by the process described in his paper is derived from the spirits of turpentine used in its preparation, for spirits of turpentine

almost always give a precipitate on addition of petroleum ether, which precipitate is, after drying, soluble in carbonate of soda. I have ascertained that the residue left from the petroleum ether extract or the whole of the bitumen without intervention of spirits of turpentine do not give anything to soda, except, perhaps, invisible traces.

Asphalts invariably contain some sulphur and nitrogen, and while I was in the belief that these all pass off with the petrolenes, I found them later on in all products if they once were incorporated.

In many asphalts sulphur may be almost entirely removed by washing with water. If such asphalts, however, are refined, *i. e.*, heated to a considerable degree before washing, the bitumen will contain sulphur, and this sulphur will pass through the whole series of products. In what form this sulphur exists I am not prepared to say, nor do I know in which form the nitrogen exists, except that I have so far not been able to extract from asphalt nitrogenous basic substances.

Sulphur does not act in asphalt, as Lefkowitch, of London, says, when he suggests that it plays the same role in asphalt as in the vulcanization of rubber. It would be interesting to hear on what data his belief is founded.

I have shown, also, that the belief of others is not well founded in this respect. So-called analyses which were made to prove the fact and likewise deny my assertion of the presence of oxygen in some asphalts I have shown to be unreliable.

For instance, Richardson, in the *Journal of the Soc. of Chem. Industry*, 1898, p. 20, shows how he calculates the composition of the organic substances in asphalt in the following manner:

	As Obtained.	Organic Matter.
Carbon	10·60	52·65
Hydrogen	1·55	7·69
Sulphur	2·08	10·32
Nitrogen	0·42	2·05
Mineral matter (ashes)	79·85	—
Oxygen by difference	5·50	27·29

It is certainly quite original with him, but I am inclined to think that his lead will not be followed.

Sulphur is, in my opinion, in asphalt for the reason that sulphates have passed their oxygen for the oxidation of organic matter. It is not the determining substance, but an incident, a residue from a chemical reaction, the same as we look upon sulphates as the sources of pyrites in bituminous coal or other carboniferous minerals.

In order to show that it is the oxygen mainly which produces the bitumen, I have undertaken to prepare asphalt from petroleum under conditions which prevent sulphur from acting on the organic material.

The material used by me were heavy lubricating oils from the Standard Oil Company. 100 grams of this were treated with a solution of 300 grams bichromate of potash, 600 grams sulphuric acid, 2 liters of water.

The mixture is frequently agitated and kept upon the water-bath for from 2–4 months. The oil gradually thickens and takes the characteristic odor of asphalt. An examination of the products led me for the first time to an asphaltic acid with 23 per cent. of oxygen.

It is only quite recently that this product was obtained by me from some Western natural asphalts (Kentucky).

A good deal has been said about the peculiarity of asphalt solutions containing mineral matters. All explanations made so far are surmises due to a desire to explain the phenomenon on the basis of other well-known facts. Work to explain it has not been done, partially, perhaps, for the reason that the really bituminous portion of asphalt is the subject of greatest interest. The precipitate which I produced in the petroleum ether solution by the addition of more petroleum ether contains generally about 10–12 per cent. sulphur and much mineral matter.

My method of analysis consists:

(1) Extraction of all bitumen by chloroform.

(2) Evaporation of volatile hydrocarbons in a current of carbon dioxide from the extract.

(3) Direct determination of carbon, hydrogen, sulphur and nitrogen and calculating oxygen by difference.

(4) Determination of asphaltic acid as a check.

In answer to question of Professor Day, I would state that

I anticipate that the use of steam in the place of carbonic acid for the purpose of evaporating the petrolenes will be a good equivalent. I have used carbonic acid for convenience.

I never used nitrogen.

In answer to inquiry, I would state that I determine nitrogen by Kjeldahl method.

For the determination of sulphur I treat the asphalt in a capacious platinum crucible with fuming nitric acid. The asphalt, though still liquid when hot, is comparatively brittle when cold, and can then be mixed most intimately with nitre and soda. After drying in the air-bath I deflagrate and then proceed as usual.

In answer to the remark of Professor Sadtler that asphalt is changed during the process of refining, I would state that I agree with him. The cause of such changes is the presence of the non-bituminous impurities in asphalt, partly pertaining to the mineral matter.

Extracted and purified bitumen is quite stable under the influence of temperatures used in refining asphalts. These temperatures can, therefore, be safely applied in analysis.

DR. S. P. SADTLER stated that he was ready to admit the complexity of constitution of Parianite or Trinidad pitch as maintained by Professor Peckham, in that it probably contained some of the mineral bases in an organic combination whether we concede that the organic substance is really humic acid or not; that it was, moreover, so unstable that it could not be heated directly without some decomposition. However, he did not think that this complexity applied to all natural bitumens—he recalled the natural bitumen of Uvalde County, Tex., which could be extracted from the limestone rock, in which it occurred naturally, by the use of a naphtha solvent; that the same was true of the natural bitumen of Santa Barbara County, Cal., where the Sisquoc asphalt was extracted in that way; that he had analyzed a natural bitumen from Joplin, Mo., occurring in the cavities in the zinc-bearing rocks, which was also almost entirely soluble without residue in petroleum naphtha. With reference to Dr. Peckham's method of analysis of

bitumens, he was not satisfied that turpentine was to be depended upon as a desirable solvent. It was obvious that freshly-rectified spirits of turpentine, and that which had been exposed to the air for a time as warm turpentine upon a filter and had in consequence become somewhat resinous, would have distinctly different solvent powers. He had had occasion, in connection with another matter, to test this difference between turpentine free from resin and turpentine carrying resinified products, and knew that it affected the solvent action notably. To use turpentine, therefore, one would have to note its optical constants so as to insure its entire uniformity.

Dr. Sadtler stated that he had at one time proposed acetone as a solvent in asphalt analyses in place of petroleum ether, because it could be had of fixed boiling point and perfect purity, but found that its solvent power varied from that of petroleum naphtha, and therefore no longer tried to use it as a substitute. What is wanted is a study of the action of a series of solvents of fixed purity upon different natural bitumens.

DR. WM. C. DAY:—It seems to me that Professor Peckham's method of analysis of asphalts is capable of yielding valuable results, particularly when applied to Trinidad asphalt, which is in a number of respects unique. The paper indicates that the alumina found in the mineral matter of the asphalt is present not as a constituent of clay, but as a base in salts of organic acids. This result is certainly interesting, and by itself would justify the entire investigation and the proposal of this method of analysis. I, for one, would be glad to see the method extended in its application. I should think, however, that the directions for carrying out the various separations should be as exact and specific as possible, since some of the solvents used are more or less variable in their chemical constitution and also in their solvent action, according to the temperature at which they are applied.

* * * * * * *

The need for uniformity in the method of analysis of asphalts is very great; this applies to elementary analysis

as well as to the analytical separation of compounds and groups or classes of compounds. I hold in my hand an interesting paper, by Mr. Clifford Richardson, with which I have no doubt you are all familiar. A table of elementary analysis of asphalts is given, in which oxygen is not mentioned as a constituent element. His results in the case of Utah gilsonite differ so markedly from a number that I have obtained with the same substance, that I am at a loss to account for the discrepancies. He finds nitrogen in Utah gilsonite 0·79 per cent., while in ten different determinations by the Gunning modification of the Kjeldahl method I find an average of 2·40 per cent., with extremes of 2·25 and 2·52, generally nearer the latter figure. I think if those who are investigating asphalts could get together and agree on uniform methods of analysis and calculation of results, the cause of asphalt investigation might be benefited.

DR. H. F. KELLER made some comments in the discussion, referring more particularly to the remarks of Dr. Day and Dr. Endemann. After the former's reference to the disagreement of the nitrogen determinations in various asphalts, and the manner in which they had been made, Dr. Keller suggested that more concordant results and certainly more reliable figures might be obtained by combustion of the material with copper oxide than is possible with the Kjeldahl method.

With reference to Dr. Endemann's statement that the treatment of asphalts with solvents could not be regarded as an analysis, Dr. Keller called attention to the fact that his method does not permit the separation of individual compounds any more than the use of solvents. To Dr. Keller's question whether he (Dr. Endemann) had made any attempt to isolate any compounds of definite composition he replied negatively.

MR. ALFRED H. ALLEN, Sheffield, England [Correspondence]:—I am duly in receipt of your letter of the 8th instant, accompanying the advance copy of Professor Peckham's paper on Parianite, for which I am obliged.

I have read the paper carefully, and am glad that the difficult subject of the constitution of asphalt continues to

receive the enlightened attention of Professor Peckham. I think every one must agree that much remains to be done in the way of isolating the proximate constituents of asphalt, and the non-crystalline character of the products renders their isolation in a state of purity a matter of peculiar difficulty.

I quite approve of Professor Peckham's remark that an examination of the nitro-derivatives of the various fractions isolated by the action of solvents affords a promising field for research. I would go further than this, and suggest the investigation of the bodies produced by the action of bromine, preferably in solution in carbon tetrachloride.

It has been frequently observed that the crystallization of organic bodies has prevented the presence of very small proportions of impurities. I do not know whether any attempt has been made to purify the various fractions obtained by the action of neutral solvents. If not, I would suggest that the solutions of these fractions should be agitated with weak acid and alkali with the view of removing traces of substances of alkaline and acid character. It would also be interesting to know how far nitrogen, oxygen and sulphur enter into the composition of any of the fractions obtained by Professor Peckham and Miss Linton; in fact, I am rather struck by the absence of any elementary analyses of the products obtained.

It is evident that plenty of work remains to be done on this interesting but difficult subject, and I shall watch with interest the further progress made by Professor Peckham and his able collaboratrix.

PROF. PECKHAM:—The use of spirits of turpentine was first suggested by the directions given in the first edition of Allen's "Commercial Organic Analysis." It is directed there that the bitumen in European asphaltic rock be dissolved from the mineral matter in freshly distilled Russian turpentine. The turpentine should be freshly and doubly distilled. In any case the filter should not be digested in turpentine, which, poured upon the filter while hot, has been allowed to get cold. The stopcock in the funnel should be closed, the filter filled with boiling turpentine, the stopcock imme-

diately opened and the hot turpentine allowed to run off as rapidly as possible. This should be repeated until the turpentine is discharged colorless. There are very great differences observed in the action of boiling turpentine upon asphaltums and bituminous minerals from different localities. In some cases the solution is as readily affected as sugar and water; in other cases the solution takes place much more slowly. The points made by Drs. Endemann and Sadtler are theoretical, not practical; any other solvent, as, for instance, any of the benzole series that will dissolve the material not soluble in petroleum ether, will yield this precipitate on dilution with a large excess of petroleum ether. I have digested this precipitate in dilute hydrochloric acid, then in a dilute solution of sodium hydrate, which became highly colored, and then obtained a copious precipitate of an organic acid, in brown flocks, when the sodium hydrate solution was acidulated.

It is true that on the large scale the bitumen of the Uvalde County bituminous limestone has been extracted with petroleum naphtha, yet I have never found among the many samples of this rock that I have tested a single sample in which the bitumen was all soluble in petroleum ether. It is, however, practically, all soluble in boiling turpentine. On the large scale, the portion insoluble in petroleum ether is washed out of the rock by the solution of the remainder in the petroleum naphtha, and the purified bitumen consists of a mixture of the two solubles.

I have for some time been of the same opinion, so well expressed by Dr. Sadtler, that "What is wanted is a study of the action of a series of solvents of fixed purity, etc." I have in hand the material for precisely this work, but have hitherto been unable to devote to it the necessary time.

I also recognize the force of Mr. Allen's remark concerning the absence of elementary analyses. The reason is that hitherto I have not been able to obtain the substances described in this paper under such conditions and in such quantity as to make ultimate analyses advisable. Ultimate analysis should follow the study of the action of solvents of fixed purity. I have for some time been planning the

use of one of the pure paraffines, of low boiling-point, the solution obtained being fractionated in vacuo and treated as if it were a crude petroleum or naphtha. The action of pure alcohols, both absolute and of definite dilution, as well as of the benzole series in pure forms, is to be studied both separately and in series. There is work enough on these problems to fill the twentieth century.

Stated Meeting, held Tuesday, April 18, 1899.

ON SERIES IN SPECTRA.

BY DR. EDWARD A. PARTRIDGE.
Professor of Physics, Central Manual Training School.

The investigation of relations between the spectra of different elements has been a favorite subject of inquiry ever since spectra have been studied. No one can attentively examine drawings of the spectra of a series of related elements without being impressed with their general similarity.

Lecoq de Boisbaudran* was the first to give a detailed description of this similarity. He did this in a number of articles in the *Comptes Rendus* of 1869. In 1886† he published a method by means of which he calculated the atomic weight of germanium from its spectrum. He writes as if he had known the law for a long time, but I can find no evidence of it having been published before 1886. His statement of the law is as follows:

"In the natural families of elements the variation in the increment of the atomic weight is proportion to the variation in the increment of the wave length of homologous rays or groups of rays in the third harmonic of the spectrum."

Ames‡ examined this statement critically, and found

* *C. R.*, t. 69, pp. 445, 606, 694, 1869.
† *C. R.*, t. 102, p. 1291, 1886.
‡ *Phil. Mag.*, 30, 33, 1890.

that it cannot be considered general, although it may apply roughly to certain groups of lines.

One difficulty is to pick out those lines which are to be considered homologous. This is not an easy matter in complicated spectra.

The recognition of the fact that the spectrum of an element depends upon the structure of the molecule and atom of the element gave hopes of learning something of that structure.

Light, being a periodic phenomenon, calls up visions of a vibrating system causing the light.

Here, then, is the problem: from the spectrum of an element to calculate the structure of its molecule and atom. The cognate problem in sound would be: from the combination of tones emitted by a bell to calculate its size and form, the density and elasticity of the material of which it is made.

The acoustical analogy has, however, hindered rather than helped progress in that direction, for it encouraged investigators to seek for simple harmonic relations between the frequencies of the vibrations given out by a molecule. Harmonic relations are to be understood as meaning whole number ratios, such as exist between the fundamental and overtones of an organ pipe or a piano string. This point has been emphasized, since the term harmonic has been frequently used to indicate simply a relation, no matter what the law of the relation might be.

The idea of harmonic relations existing between the frequencies corresponding to the several lines of a spectrum existed as a part of common knowledge among spectroscopists for a long time. Lecoq, Soret, Stoney and Liveing and Dewar sought such relations. We remember reading in the popular literature of ten or fifteen years ago that the three prominent lines in the visible H spectrum are related as C, F and A of the musical scale are related. Stoney* announced, in 1871, that the frequencies of $H\alpha$, $H\beta$ and $H\delta$ are to each other as 20 : 27 : 32. Similar relations

* *Phil. Mag.*, 41, 291, 1871.

have been announced for other series in other spectra. But all the harmonics are never present, and several fundamentals have to be supposed in order to include a considerable number of lines in the scheme.

With greater refinement of measurement these relations were seen to be only extremely rough approximations. In order to test the question finally, Shuster,* in 1881, proposed the following problem: "Is the number of whole number ratios between the wave numbers greater than would exist if the lines were distributed at random?"

By the calculus of probabilities he found the number of approximate whole number ratios that is to be expected with lines distributed at random. He included in his calculation of whole number ratios all numbers under 100, and the degree of approximation to the exact ratio, in order that it might be called a whole number ratio, was that it should fall within the limits of error of observation at that time. He applied his results to the spectra of *Mg*, *Na*, *Cu*, *Ba*, and in particular to *Fe*, and calculated 10,000 ratios of frequencies. But the number of whole number ratios was less than would be expected on a chance distribution. Now that this question could be regarded as settled, attention was turned to other relations which had long been suspected, but which could not be established in consequence of insufficient refinement in the measurements.

In 1869 Mascart† called attention to the fact that the well-known doublet, the *D* line of *Na*, was repeated six times in the spectrum of that element, and he also stated that the distance between each pair was approximately the same. Later, he noted that the "*b*" triplet of *Mg* is repeated three times in the ultra violet.

In 1871 Liveing and Dewar observed the *Na* doublets, but stated that the distances between the lines of the doublets follow no law. In 1882‡ Shuster said that the differences between the corresponding lines in the triplets

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* *Proc. Roy. Soc.*, 31, 337, 1881.
† *C. R.*, 69, 337, 1869.
‡ *Brit. Ass'n Report*, 1882, 120.

of *Mg* were not regular. In 1883,* however, Hartley proved that these distances are the same; that is, naming the lines in a triplet *a*, *b* and *c*, the distances *a b* and *b c* in one triplet are the same as the corresponding distances in all the triplets. But *a b* is in general different from *b c*. This law he proved for the triplets of *Mg*, *Zn* and *Cd*. I must next describe some work in another field of spectroscopy.

The discovery by Huggins,† in 1876, of the *H* series in the ultra-violet spectra of the white stars exerted a powerful influence in the direction in which much progress has been made. In the *Philosophical Transactions* for 1880 he published an account of his work on this subject. Appended to this article is a note by Stoney, who showed by drawings that there was a high degree of probability that the newly-discovered lines were due to *H*. Cornu‡ afterwards, taking great care in the preparation of pure *H*, proved that the new series was due to that element.

Liveing and Dewar,§ and Cornu noticed series in the spectra of other elements, which resembled the *H* series, and in 1885 Cornu‖ established a relation between the series of *Tl*, *Al* and *H*.

Cornu's relation turns out to be only a rough approximation; it is that

$$\lambda_{Al} = A + b\,\lambda_{H}.$$

Cornu picked out for consideration the easily reversible lines in the spectrum. He tells how he had endeavored, without avail, to find a formula which should express the relation between the lines in the spectrum of an element, and concludes that the quickest way of arriving at the law would be to follow Kepler's example, and try hypothesis after hypothesis in the hope of ultimately achieving success. On account of its simplicity and importance in stellar spectroscopy the *H* spectrum has always attracted a large share

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* *Jour. Chem. Soc.*, 43, 390; 1883.
† *Phil. Trans.*, 672, 1880.
‡ *C. R.*, t. 100, p. 1181; 1885.
§ *Proc. Roy. Soc.*, 29, 30, 1880; *Phil. Trans.*, 31, 1881.
‖ *C. R.*, 100, 1181, 1885.

of attention. In 1885, the same year in which Cornu recounted his unsuccessful attempts at finding a law, Balmer,* of Zurich, published a formula by which the wave lengths of the *H* lines are expressed as simple functions of the integars 3, 4, 5, 6, etc. The formula was originally calculated to express the wave lengths of the *H* lines in the visible spectrum, but was found to apply as well to the lines discovered by Huggins, in the white stars. The formula is

$$\lambda = \lambda_0 \frac{m^2}{m^2 - 4}$$

λ_0 is a constant, and the whole numbers 3 and following are to be substituted for m.

This formula shows as well as Stoney's drawings that the lines asymptotically approach the limit λ_0, which is the value of λ for $m = \infty$.

The accuracy of this formula is surprising, as it gives the wave lengths to a high degree of approximation. In 1888 Kaiser and Runge communicated to the British Association the fact that they had found a formula, of which Balmer's is a special case, which applied to the series of lines in other spectra.

These were the series to which Liveing and Dewar and Cornu had previously called attention as analogous to the *H* series. Kaiser and Runge found that the measurements of wave lengths that had previously been made were not sufficiently accurate for their purpose.

They say: "We saw that we were compelled to disregard all the numerical material at hand, and we concluded to determine the spectra of the elements from one end to the other." They first of all measured the spectrum of iron with the utmost care, in order that they might use it as a standard. They tabulated the wave lengths of 4,500 lines in this spectrum. Next, the carbon spectrum had to be studied in order to decide what lines were due to the carbon in the arc and what were due to the element under examination. This done, they began the investigation of the spectra of the alkali metals.

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* *Wied. Ann.*, 25, 18, 1885.

The following account of their work is taken from their papers in the *Abhandlungen der Akademie der Wissenschaften zu Berlin*, 1888–1893. An important result of their work was to disprove the statement of Lockyer that there are coincidences between the lines in the spectra of different elements. Such coincidences they never observed. From these supposed coincidences Lockyer drew the conclusion that at the temperature at which he worked the elements were dissociated, and that the common lines were due to common ingredients. No coincidences have been observed by Kaiser and Runge.

From even a cursory examination of their results the great similarity between the spectra of the alkali metals becomes apparent. According to increasing atomic weight, the alkali metals form the following series: *Li*, *Na*, *K*, *Rb*, *Cs*; this is also the series showing the relative ease with which the lines appear.

Li and *Na* appear everywhere, and it is very difficult to obtain the spectrum of *Cs*. Liveing and Dewar had found series in *Li*, *Na*, *K*. Kaiser and Runge found similar series in the spectra of *Rb* and *Cs*.

The general property of these series is that, with increasing atomic weight, homologous series are displaced toward the red end of the spectrum. These experimenters also found that the lines which form series in the spectra of the alkali metals, except *Li*, are doublets. Michelson has completed the analogy in this respect, by showing with his interferential refractometer that the red *Li* line and the red *H* line are extremely close doublets.

But the numerical relations are of much greater interest and importance than these simple analogies. Balmer's formula for the wave lengths of the *H* lines when inverted to give the wave numbers becomes $f = b - 4\,b\,n^{-2}$. This suggested to Kaiser and Runge to try the formulæ

$$f = H + Bn^{-1} + Cn^{-2}$$

and

$$f = A + Bn^{-2} + Cn^{-4}$$

Observation shows that as n increases, the frequency asymptotically approaches the limit A and that the succes-

sive lines approach each other more and more. Trial shows that with proper choice of constants the formula represents the successive lines in the series with great accuracy. This result Kaiser and Runge communicated to the British Association in 1888. They admit that the objection might be raised that an arbitrary formula with three disposable constants could represent with sufficient accuracy a series consisting of say, eight lines.

Having raised this question, they reply to it by means of an example; they apply the formula

$$a + bn^{-1} + cn^{-2} + dn^{-3}$$

containing four constants to the frequencies of the lines of the violet *K* series. They determine the constants so as to represent the first, third, fifth and seventh lines accurately, and then calculate the second line. The error is sixty times as great as with their three constant formula.

By use of their formula Kaiser and Runge calculated the position of *Na* lines that had not been observed, and later found them by careful examination of their plates. They found three series of doublets in the spectra of the alkali metals, except *Rb* and *Cs*, which have but two series. These series are distinguished by their appearance. They name them the principal series and the first and second subordinate series. The principal series contains the strongest lines of the element, and in all but *Li* this series is observed to consist of doublets, which become closer and closer as the wave number increases, the difference between the wave numbers of the components of the doublets being about inversely proportional to the fourth power of the number of the doublet in the series.

The number three is the least number for which the formulæ have positive values, hence three is the number corresponding to the least refrangible line in the series. This line is to be regarded as the fundamental line and it was actually observed by Kaiser and Runge in 1890 in the spectra of all the alkali metals, except *Cs*, where, on account of the high atomic weight, it is in the ultra-red.

In 1892 an elaborate investigation was carried out by

Snow* by the bolometric method, with the object of testing the formula of Kaiser and Runge. He sought and found the infra-red lines of *Cs* very close to the place predicted by the empirical formula, thus furnishing a remarkable confirmation of its accuracy and illustrating its importance.

The lines in the principal series which correspond to the number 4 are in the ultra-violet, so that only the first member of the principal series is visible. The subordinate series lie in the visible part of the spectrum. The first subordinate series is diffuse and reversible, the second subordinate series diffuse on one side and not reversible. These series consist, except in the case of *Li* (due to insufficient dispersion), of doublets which are a constant distance apart in the spectrum of any element. It has been possible to arrange all the lines of *Li* and *Ka* in these series. In the cases of *Na* and *Rb* one doublet remains to be assigned to a place. About the same time that these researches of Kaiser and Runge on the alkali metals appeared, the Swedish Academy of Sciences published an important and elaborate paper which had been presented in 1889 by Rydberg.† The law of constant differences discovered by Hartley, and the series that had been discovered by Liveing and Dewar, formed Rydberg's point of departure. He first of all picked out the doublets and triplets in spectra and separated them into series according to the indications of Liveing and Dewar, who had recognized the nebulous and sharp series. Then he constructed a curve for each series; these curves are similar to that used by Stoney in 1880 to identify the lines discovered by Huggins in the white stars as *H* lines. The form of the curves shows at once that there are asymptotes parallel to the axes, and hence recalls the equilateral hyperbola. Rydberg then, by a careful induction, arrives at a general formula which is a modified form of the equation of the equilateral hyperbola.

The principal results obtained by Rydberg are stated by

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* *Physical Review*, 1, 28, 1893.

† Rydberg. *Kongl. Svenska Vetenskaps Akademiens Handlingar*, Bande 23, No. 11, 1890.

him as follows: In the spectra of the elements hitherto examined the strongest rays form series which are represented to a high degree of approximation by the equation

$$n = n_0 - \frac{N_0}{(m + \mu)^2}$$

where n signifies the wave number, m the number of the ray in the series $N_0 = 109721{\cdot}6$, n_0 and μ are constants which are characteristic of the particular series.

In the spectrum of each element there are two series of doublets or triplets. These series are respectively diffuse and sharp. It addition, there is a principal series composed of doublets which approach each other as we pass to the more refrangible end of the spectrum. The principal series contains the strongest lines of the spectrum, the diffuse series is next in strength and the sharp series is weakest.

An interesting and important relation exists between the principal and the sharp series. This relation is expressed by the following formula:

$$\pm \frac{n}{N_0} = \frac{1}{(m_1 + \mu_1)^2} - \frac{1}{(m_2 + \mu_2)^2}$$

If in this formula we make $m_1 = 1$ and give successive integral values to m_2, then n represents the frequencies in the principal series. On the other hand, if m_2 equals 1 and we give successive integral values to m_1, we obtain the sharp series.

The wave lengths of corresponding lines, the distances between the components of doublets and triplets as well as the constants n_0 and μ in corresponding series in the spectra of different elements, are periodic functions of their atomic weights.

The series in the spectra of any one element are related in a way which proves that they belong to one system of vibrations. The periodic relation between the constants of the formulæ for corresponding series in different elements allows the calculation of the spectrum of an element when the spectra of the adjacent members in the periodic system are known.

Rydberg remarks that the hypotheses of Lockyer on the

dissociation of the elements are quite incompatible with the results of his researches. Lockyer's observations on *Na* and *K* only prove that with luminous atoms, as with sounding bodies, the relative intensities of emitted radiations may vary under different circumstances; for the lines in question belong undoubtedly to the same system of vibrations.

Concerning this paper by Rydberg, Kaiser and Runge make the following remarks:

They did not find his formula to be more fitting than their own, nor did they find that Rydberg's constant N_0 was an absolute constant, but that it varied a little like their B, which only varied 22 per cent. in the elements examined.

The next contribution of Kaiser and Runge deals with the second group of the periodic system.

Their results on this group were published in 1891. The series in the spectra of this group of divalent elements consist of triplets, with constant differences for each element. The series corresponding to the principal series of the alkali metals are not found, but the analogy between the series actually found and the subordinate series of the alkali metals suggested that they should be named subordinate series.

The spectra of *Mg*, *Ca*, *Zn*, *Cd* and *Hg* each show two subordinate series of triplets which end at the same point for $n = \infty$.

Sr shows but one series, and *Ba* none.*

The behavior recalls that of the alkali metals, in that *Rb* and *Cs* show but one subordinate series.

The production of the full spectrum seems to become more difficult with increasing atomic weight. In the spectra of all of the elements of the second group there is a considerable number of lines which do not fall into the general scheme.

The homologous series show the same shifting toward the red end of the spectrum that is noticed in the first

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* In 1893 Rydberg, using Kaiser and Runge's measure, found the second subordinate series of *Sr*.

group. To what extent the series of the elements are periodic functions of the atomic weight, Kaiser and Runge say they could not conclude from the small number of elements examined, but they remark that if the wave lengths for $n = \infty$ in the homologous series are used as ordinates and the atomic weights as abscissæ, a curve will be formed which is quite similar to the curve of atomic volumes given by Lothar Meyer.

In 1891 Kaiser and Runge published their results on *Cu*, *Ag* and *Au*. They found far less regularity than in the spectra of the alkali metals. The spectra of *Cu* and *Ag* show two subordinate series which end at the same point for $n = \infty$.

In addition, in both spectra there is a strong ultra-violet pair, which may be the first of the principal series. Gold shows no series, but does show the strong ultra-violet pair homologous to the isolated doublets of *Cu* and *Ag* just mentioned.

The greater or less perfection with which the series in the spectra of the elements are developed may, perhaps, be partially explained by the following consideration:

The elements, when heated to the temperature of the electric arc, are in very different relative states. The absolute temperature of all is the same, but they are not at corresponding temperatures, that is, at temperatures equally removed from their melting points. Now it is with the elements of highest melting points that the series are least perfectly developed, which would indicate that the temperature of the arc is not sufficient to bring them out. In general, the lower the melting point the more perfect is the development of series in the spectra. This fact is illustrated by the following table:

Element.	Melting Point.	Percentage of Lines which Fall in Series.
Ba	1600	0
Au	1200	4
Cu	1050	6
Ag	960	26
Sr	700	20
Ca	700	34
Mg	600	64
Zn	410	80
Cd	320	50
Li	180	100
Na	90	100
Cs	62	100
K	58	100
Rb	38	100
Hg	40	27

In 1892 Kaiser and Runge published their results for *Al*, *In* and *Tl*. As in the other groups of elements, and as had been found previously by Rydberg, they found two series of doublets in the spectra of each. These are respectively diffuse and sharp, ending at the same place, and therefore analogous to the subordinate series of the alkali metals.

In 1893 they gave the results which they had obtained for *Sn* and *Pb*, *As*, *Sb* and *Bi*. They did not find the regularity which they had established for the first three groups of the periodic system. Nevertheless, these spectra exhibit a certain order, since there are groups of lines whose frequencies differ by a constant. They state in a foot-note that *Mn* is the only element not in the first three groups whose spectrum contains two series of triplets.

In 1896 Runge and Paschen studied the spectrum of helium, and found that it resembled the result that would be obtained by superposing the spectra of two alkali metals, that is, they found two principal series and four subordinate series. They drew the conclusion that the gas consists of two elements, and adopted the names helium and parhelium for them.

In 1898 the same observers studied the spectra of *O*, *S* and *Se*. The spectrum known as the compound line spectrum of *O* was the one investigated. It was found to consist of series analogous to those of the other elements. They found six series, as in the case of helium, hence their conclusion from spectroscopic evidence that helium is a mixture does not hold. *S* and *Se* also show indications of two principal series, but each shows only two subordinate series. For the determination of the lines which belong to the principal series they used the relation discovered by Rydberg between the sharp subordinate series and the principal series. This relation is given above in the account of Rydberg's memoir of 1890, but in another form it is somewhat more easily appreciated. The relation is this: The difference between the wave numbers of the common limit of the subordinate series and the limit of the principal series is the wave number of the first member of the principal series.

Thiele published in 1897 and 1898 two papers dealing with the subject of series in spectra. The first paper states that he finds that the formula expressing the relation existing in spectra is some function of $(n + c)^2$

$$\lambda = f\,[n + c]^2$$

In the second paper he resolves the third carbon band into series.

Up to 1896, the hydrogen spectrum was considered anomalous, since it contained but one series of lines. In the above year, however, Pickering* discovered a new series of lines in the spectrum of ζ Puppis. This series ends at the same point as the well-known series of the hydrogen spectrum and is hence the second subordinate series of that spectrum. Up to the present time these lines have not been produced in the laboratory.

An important fact showing the correctness of the work that has been done in resolving spectra into series was discovered by Humphreys† in 1897. In investigating the shift toward the red end of the spectrum that is produced by

* Pickering. *Astrophysical Journal*, 5, 92, 1896.
† Humphreys. *Astrophysical Journal*, 6, 233, 1897.

increasing the pressure of the gas in which the arc giving the spectrum is placed, he found that the lines in any series have the same shift; that is, since the shift is proportional to wave length, if the shifts of the lines are divided by their wave lengths the results will be constant for all the lines in any one series. But the amount of the displacement is different for lines belonging to different series, although they may have approximately the same wave length. The first subordinate or diffuse series is shifted about twice as much as the principal series and the second subordinate or sharp series about four times as much as the principal series.

PHOTOGRAPHIC AND MICROSCOPIC BRANCH.

Stated meeting held November 8, 1899.

PHOTOGRAPHIC RECORD WORK.

DISCUSSION.

The Chairman, Dr. Henry Leffmann, announced the subject for discussion and invited Dr. Charles F. Himes to open the subject.

DR. HIMES spoke as follows:—The possibilities of photography as an art preservative were fully realized at the first announcement of its discovery. It promised to supplement the printed page in a way that the most skilful and conscientious artist could never hope to do. The authorities of the Congressional Library, at Washington, doubtless had this in mind when they very appropriately associated the names of Guttenberg and Daguerre near each other in the saloon of inventors, a fact, by the way, that seems to have escaped the notice of many at the recent meeting of the Photographers' Association of America, where, after an animated, almost indignant, discussion, resolutions were passed, and a committee appointed with power to correct the supposed omission of recognition of the inventor of photography.

Whatever may be thought of the adaptation of photogra-

phy to artistic expression, it is just that that unfits it most for art, that gives it its high value for observation and record work. The artist or the draughtsman can employ a sort of rhetoric of art, a way of putting things, to accentuate what he wishes, and with a purpose in view. He can close his eyes to the undesirable or disagreeable, but as a record his work is always necessarily incomplete; for at his best he does not and cannot give all that he sees, and what he does give is always colored by personal bias and interpretation. The camera, on the other hand, without sense of beauty or even sense of propriety, with no point to make, no preference to emphasize, with inability to reject any more than to select, is necessarily mathematically, even painfully, accurate into the minutest details, giving a complete record with the unerring precision of a machine. The importance for record of facts of this degree of completeness, so annoying to the artist, is apparent upon reflection, that as no condition in a phenomenon or experiment may be regarded as trifling, hardly even relatively so, so for the purpose of record there is no detail in the pictorial representation of a fact, however minute, that can safely be treated as trivial, or incidental. What may be misinterpreted, or entirely overlooked to-day, may to-morrow assume the highest importance, even prove to be the germ of a new branch of science. Great discoveries often spring from such incidental facts. How many inexplicable defects on photographic plates, that were supposed to have been carefully shielded in the neighborhood of Crookes tubes, turned out, in the after-light of Roentgen rays, to have been unrecognized pointers to that discovery.

Whilst the characteristics of photography alluded to were recognized at the very beginning, complete realization of expectations based upon them necessarily awaited fuller development of the art; but its progress, in very recent years, has been so rapid, in all that fits it for record purposes, that unless we reflect we can hardly appreciate its present resources in this respect, and the widened range of possible subjects. To note briefly some of these points of advance:

(1) The time required or permitted by it to make an observation and record it, for it does both, formerly within very narrow limits, to-day lies between extremes almost infinitely separated. It can record the phenomenon that lasts but an instant, which the eye cannot recognize, and, on the other hand, since the perfecting of the dry plate, it can look and look, not only with unwearying retina, but with cumulative effect, by the hour, if necessary, bringing into range of observation and record facts luminously too faint ever to come within the range of direct vision.

(2) Color has ceased to be a matter of much concern. Orthochromatic plates will reproduce the discolored, the faded, the visually indistinct, or even invisible.

(3) Local illumination, and time of day or night, have become very secondary matters in many cases, by reason of the ready response of modern plates to the various convenient artificial illuminants, as magnesium light, electric light and even gas light. Thus the interior of the pyramids and of mines, the alcoves of libraries, the well-lighted studio have become practically alike.

(4) Inaccessible places of photography have come to mean only those inaccessible to man. Freed not only from the impedimenta of tents, solutions, etc., of the olden time, but even from the changing bag and heavy and fragile glass, the camera has become equally the *vade mecum* of the glacier wanderer and the ordinary traveller.

(5) The division of labor which the modern dry plate permits allows the exposure to be made by the one who knows best what is wanted, or who may have opportunity, and the development to be made by the one whose technical knowledge and skill may elicit the best results. As an illustration from my own experience, some years ago, after having carried the camera to one of the most rugged points in Switzerland, to obtain a series of views of a glacier system, on my return, although I had perhaps as large and successful experience in development of dry plates then as most amateurs, for want of time, combined, I confess, with some want of faith in the plates, I readily committed their development to Mr. W. H. Rau, and I am fully satisfied

that he obtained delicacy of results that I would have fallen short of.

The topic, "Photographic Record Work," announced for discussion this evening, I take to be, then, the most complete utilization of photography for making and preserving records of facts—using the word fact in its broadest sense. This term has been introduced from England, where considerable attention has been given to this application of photography in the past few years, first, under the rather ambiguous name of "survey work," by local photographic associations, and more recently by the National Photographic Record Association, recognized by Parliament, with the British Museum as its depository. According to its constitution, and announcements made of its work from time to time, it is confined, almost exclusively, to work of a general historical character.

Thus, among the contributions of Sir Benj. Stone, M.P., who has been especially active, are photographs of interesting parts, relics and documents from the Palace of Westminster, of ancient ceremonies of state at the Tower, survivals of mediæval usage still observed, of municipal records of London, of the warrant for the execution of Charles I, showing many erasures, and from the Vatican archives, of love letters of Henry VIII to Anne Boleyn, as well as of the treatise that earned for him the title Defender of the Faith.

Whilst this is most important work, and is not conducted as systematically, to any extent, in this country, I think there is an equally inviting special field of activity open to the Franklin Institute, and a practical plan in operation here might be of further service in aiding, as well as stimulating, societies more distinctively historical in the prosecution of work more similar to that of the British associations. But for the Franklin Institute, peculiarly, the time seems opportune for, indeed almost demands, the beginning, at least, of a collection of photographs of scientific and industrial subjects that with time would become as unique in interest and value as the library of the Institute has become. Whilst such a collection might and should, of

course, contribute to the rescuing and fixing permanently of rapidly disappearing, or endangered, records and land marks of scientific and industrial history, by the duplication of old documents and records, photographs of historical pieces of apparatus and machinery, portraits, etc., etc., never to be acquired too soon, I think, however, the main purpose should be to make as complete, systematic, practical pictorial record of scientific and industrial facts of the day as they occur. We make scientific and industrial history as rapidly as civil history, and should be, at least, equally careful for its preservation, for, unless human nature changes, the end of the twentieth century will want to know as much and as minutely about the beginning of it as we do now about that of the century just closing. We must now be satisfied with drawings of that period, often crude, and always limited in numbers; they can expect from us no less than the increased facilities for pictorial representation of to-day entitle them to. Perfected photography, if I may so call it, has made this a picture-reading age, and it is becoming more and more a picture-demanding age. Just as the business man in this type-writing age turns, almost instinctively, from the written communication, so even the scientific man will turn more and more from the purely descriptive page to the pictorial page, which is not only abbreviated description, but by aid of photography may have much needed completeness of details and highest authenticity. As an illustration, with a local interest of its own, I have here a photograph of a piece of apparatus devised and used in investigation by Prof. Walter R. Johnson, of the Franklin Institute, about seventy years ago, which he called a rotascope. It has been appealed to, and substantiates his claim to the invention of the gyrascope some years before Foucault. Professor Johnson was appointed on the Perry Japan expedition, and sold his apparatus, which was bought by Dickinson College. For some reason, however, he did not accompany the expedition. More than thirty years ago, upon assuming a chair in Dickinson College, I encountered this strange apparatus. Professor Baird, a predecessor, then in

the Smithsonian Institution, gave me the facts as stated. I rummaged the journals of that period, found the description, figure, and account of investigations made with it. One piece—the orbital rod—was wanting. A piece of mahogany on the scrap heap was recalled, which I had had once in hand to fashion into something else, but which had been placed aside because of manifest evidence of contrivance and design. It proved to be the missing part in the performance of an experiment demonstrating the tendency of a body rotating on an axis and at the same time revolving in an orbit, to conform the axial motion in direction to that in the orbit. In connection with this, attention was called to the fact, mentioned by Biot and others as singular, that the heavenly bodies all rotate on their axes in the same direction as they revolve in their orbits, attributed to the first cause of motion, and also to geological theories based on changes in the position of the polar axis. It is in itself an exceedingly interesting experiment. The heavy wheel of the rotascope, put in motion in any position, soon assumes a position with its axis perpendicular to the plane of orbital motion, and with a motion conformable to it; and upon reversing the orbital motion, it soon wabbles with apparent discomfort, and finally reverses its vertical position, and this reversal can be effected several times before it comes to rest. The case should be capable of mathematical statement and solution. But to return to the point, from which we have been led into a longer digression than was intended by the interest incidental to the subject, the account given in the *Journal of the Franklin Institute* (December, 1831) is accompanied by a careful drawing; but it does not represent the apparatus as actually employed. Probably no piece of apparatus ever was constructed on the model figured. It may be regarded as idealized, as was not only allowable, but natural. But this photograph of the more crude actual apparatus possesses a character and authenticity, as well as historic interest, that the drawing does not. What I would suggest in cases of this kind is not that the author be deprived of the privilege of an ideal drawing, but that such drawings be supplemented, in many cases,

by photographs of the actual apparatus, not a complete edition of photographs, but at least one to be inserted with the article and the drawing in the bound volume of the *Journal* preserved in the library of the Institute. There are many other subjects even more susceptible of such photographic supplementation, which would give to the volumes of the *Journal* in the library a completeness and authenticity for record and reference not only unique, but of possible incalculable value, and at but nominal additional expense.

Among such subjects of even greater interest are many ephemeral in character, as exhibits of apparatus illustrative of processes, methods, etc., made before the Institute and its several sections, that have more than a passing interest, sometimes in connection with elaborate lectures and public demonstrations of epoch-making discoveries. Accounts of these are published in the *Journal*, reinforced as far as they can be with liberal illustrations, but such displays of apparatus, and the carefully arranged lecture table that has often absorbed much time and thought and expense, could be fixed permanently, at least as to its most important features, in a few minutes, and occasionally even some prominent scientific man, who will not live forever (in the flesh), might be caught entangled among his apparatus; though this last may be an unwise suggestion. If but a single print were made for the volume of the *Journal* in the library, and another for an independent collection of photographs of such subjects, the trouble would be repaid in a short time. Whether and in how far such photographic illustrations should be furnished other libraries or subscribers to the *Journal* might be a matter for consideration.

But such illustration of volumes of scientific periodicals, or even of books, by special photographic inserts, is secondary in importance to the accumulation of an independent, systematic, classified, indexed collection of photographs of scientific and industrial interest, from any sources, as notes for reference, and records for confirmation, arranged for convenience of reference, with proper regard for the preservation of the photographs. This last is especially important,

as the collection should consist of direct prints from the negatives, not of photo-mechanical reproductions; for although the latter have high value, they lack the quality akin to original entry, as well as the minute accuracy and possibility of magnification which belong to the photograph.

Care should, of course, be exercised in the collection for, or admission into, the collection, which, as it does not rest on pictorial value, nor even in all cases on technical excellence, but upon the record value, might contain many prosy or even at times positively ugly and inartistic pictures.

Whilst at first many subjects may suggest themselves as desirable, and efforts be made to secure them, the chief value of the accumulation will lie rather in its growth with the years, gathering up everything worth preserving, than in immediate acquisitions.

As to sizes, processes, technical excellence, etc., whilst there should be standards, recommended at least, the acceptance of any photograph offered should be based entirely on its character and desirability as a note.

There is only one other suggestion that I would desire to impress specially, namely, that provision should be made for stereoscopic pictures. It is not a question whether most or many persons are accustomed to or even can use the stereoscope, but simply as to whether such pictures have possibilities for representation and record that other pictures have not. Where position in space, or form, is to be represented, the value of such pictures is too well known to be discussed, but to emphasize the statement I submit a stereograph of a series of sparks of a Holtz machine. Either single picture presents simply a bundle of interlacing lines; both combined in the stereoscope exhibit lines of definite shape, separated and located in space. So in a single picture by the Röntgen rays there is nothing to locate an object, but by two such pictures, stereoscopically related, the object at once assumes its proper position. Soon after the discovery of Professor Röntgen I received from Professor Elihu Thompson stereographs taken by means of it, and I have here a radio-stereograph of a mouse taken by a German, which is very effective.

With this rather hurried presentation of the subject I hand it over for further discussion, knowing that there are those present who have done work unsurpassed in the reproduction of old documents and prints, and there are many points of interest to be brought out, especially the part that may be played by the representation of color in this connection.

THE CHAIRMAN:—A phase of photographic record work that has attracted but little attention, but seems to be capable of valuable applications, is the reproduction of official documents, especially those relating to property. At the present time the city of Philadelphia, for example, maintains a large force of clerks for the copying of deeds, mortgages and other papers relating to real estate. These copies are, of course, liable to error, their production takes much time and they are bulky. By photography a deed or mortgage could be copied at once and with absolute accuracy, and, moreover, in much smaller space than is now possible, which last point suggests a saving in the matter of handling and storage. Moreover, several reproductions could be made from the same negative, and kept in different places, thus rendering the loss of any set a matter of no serious moment.

MR. LOUIS EDWARD LEVY:—A photograph being in its very nature a record of the thing photographed, it follows that the subject of photographic record work is limited only by the definition of the phrase itself. If we confine this definition to the idea of recording present facts for future reference, and leave out of our purview all the many illustrative uses of photography, all its utilities as an art of graphic reproduction and all the vast domain of its æsthetic capabilities, there still remains a practically boundless field of photographic work.

Much of this field has already been surveyed by Professor Himes in his presentation of the subject. Reverting to such of its aspects as have particularly impressed me in the course of my experience, I am brought first of all to a consideration of the peculiar value of photography as a means of recording the personal data of history.

Looking around in any portrait gallery, such, for a typical instance, as the large collection of portraits from the Revolutionary epoch recently loaned by one of our public-spirited citizens for exhibition at Independence Hall, or the similar collection of pictures that hang permanently on its walls, one feels instinctively that however graphic may be these representations, they are not autographic. They are, so to speak, translations of the original theses, good, bad or indifferent, according to the competency of the translator.

They bear inevitably the impress of the translator's individuality; like all translations, they render their subject in the form of a paraphrase, which may mean more or less, or something very different from the original. The consciousness which directs the artist's hand unavoidably affects, to a more or less positive degree, his perception of his living subject, and the portrait thus produced, however skilfully it may be drawn or painted, is a reflex, not alone of the physiognomy of the subject, but also of the artist's conception, or preconception of that subject. Frequently, this preconception results in a deliberate and studied idealization, admirable enough in its way, but wholly worthless as a record of the truth of nature.

In this respect there is nothing that approaches the value of a photographic portrait. Assuming it to have been produced under a normal light and through normal instrumentalities, the photograph presents its portrait record faithfully, slavishly perhaps, but still with absolute fidelity. The photographic portrait, whatever other quality it may possess or lack, has at least the one quality of verisimilitude. There is, in fact, no other province of photography so especially its own as that of portraiture. Even though the subject be unfavorably lighted or ungracefully posed, and however deficient the picture may be in its artistic elements, the photographic portrait, unless deliberately modified by a retoucher's hand, is, in its very essence, true to nature, and, therefore, true to the truth. That minute fidelity to nature, which is the most marked characteristic of a photograph, attains, indeed, a special quality of value in the case of a portrait. The subtle verisimilitude of the photographic record affords a representation of nature whose

truth and realism no artistic idealization, however well directed or well informed, can adequately replace, and where, as in portraiture, the record to be made is that of the most subtle of all of nature's expressions, the expression of human nature, the record of the camera is at once the most impartial and the most complete.

The value of photographic portraits as data for ethnological studies, and ultimately, doubtless, for sociological deductions as well, has been fully recognized by competent biologists. For scientific purposes photographic records are, of course, alone available, but the significance of such records is forcibly suggested to us when we look upon the portrait busts of Greek or Roman leaders which have remained to us, or the physiognomies of the Middle Ages as preserved for us on the coins and painted miniatures of that period, or those of the later generations depicted for us by Dürer and others of that epoch. At the present time we have photographic portraits of only two or three generations at most. The oldest of these are the daguerreotypes of some fifty years ago, and they are but few and far between, rare heirlooms of the camera's earliest days. Nowadays, however, almost every one has a picture "taken" more or less frequently, and in time these portraits, now produced in time-proof form by various processes, will afford valuable records for the scientist's use. Already our family albums throw an interesting light on the subject of heredity, and afford extensive data for such a study of that subject as that published some years ago by the late Professor Cope in the *American Naturalist.*

There is another aspect of photography as a means of recording facts that has especially come to my notice, namely, in recording topographic changes. I was recently shown by a friend a little snapshot picture, made by him last summer at Fort Sumter, looking inward towards Charleston harbor. It happened that the point of view was almost identically the same as that from which I had myself made a stereoscopic view some twenty-five years ago. Both exposures were made at low tide, and the changes which the harbor improvement at Charleston had effected in the conformation of the landspit which is visible

at low tide were very markedly brought out by a comparison of the two photographs. Another similar instance is the change produced in the brink of Niagara Falls by the erosion of the cataract, and which may now be studied in photographs made at intervals of thirty to forty years. No drawings could render this subject with such graphic detail as do the photographs, which afford a survey at once accurate and indisputable.

In fact, surveying by photography is now being reduced to a science, but I will not further dwell upon the subject. The uses of photography for the making of scientific records are as obvious as they are many, and the field of its application is constantly widening.

MR. F. E. IVES remarked that there was still one feature that had not been touched upon, namely, the importance of the element of color in some record work. He said that the kromskop system was now being successfully employed to record and reproduce colors as well as forms in disease and surgery, and quoted Dr. Keen * to show

* A demonstration of color photography at the College of Physicians of Philadelphia, by Mr. Frederic E. Ives, took place on Wednesday evening, November 1st. In introducing the inventor, the Vice-President, Dr. W. W. Keen, called attention to the value of this method of photography as applied to several departments of medicine, especially in pathology, surgery, internal medicine and dermatology. The difficulty of reproducing by drawings the exact pathologic appearances, for example, of pneumonia, apoplexy of the brain, infarct in the kidney, cancer of the liver, etc., is very great, but a good photograph by this method would give a far better and more accurate idea of the appearance to the student. The tints are exactly reproduced, so that whether it is employed in teaching or in demonstration of specimens in connection with a paper before a society, it would be invaluable. The same would apply to surgery, as, for example, the appearance of an ulcer, of an ulcerated carcinoma of the breast, of cystitis, or the varying appearances on section of carcinoma and sarcoma.

In medicine, he was a little uncertain whether the instrument was delicate enough to show the taches rouges of typhoid, though it would probably show the petechial spots of purpura and possibly of typhus. Jaundice could be well shown, the appearance of the vaccine vesicle, the differentiation between smallpox and chickenpox would be facilitated very much by such photographs. In dermatology it goes without saying that all of the affections of the skin in which color enters could be well reproduced. It would be well if our hospitals especially would furnish themselves with outfits for the purpose of taking such photographs, and great improvements undoubtedly would follow the wide use of the method.—*Phila. Medical Journal, Nov. 4, 1899.*

the undoubted success and importance of such applications.

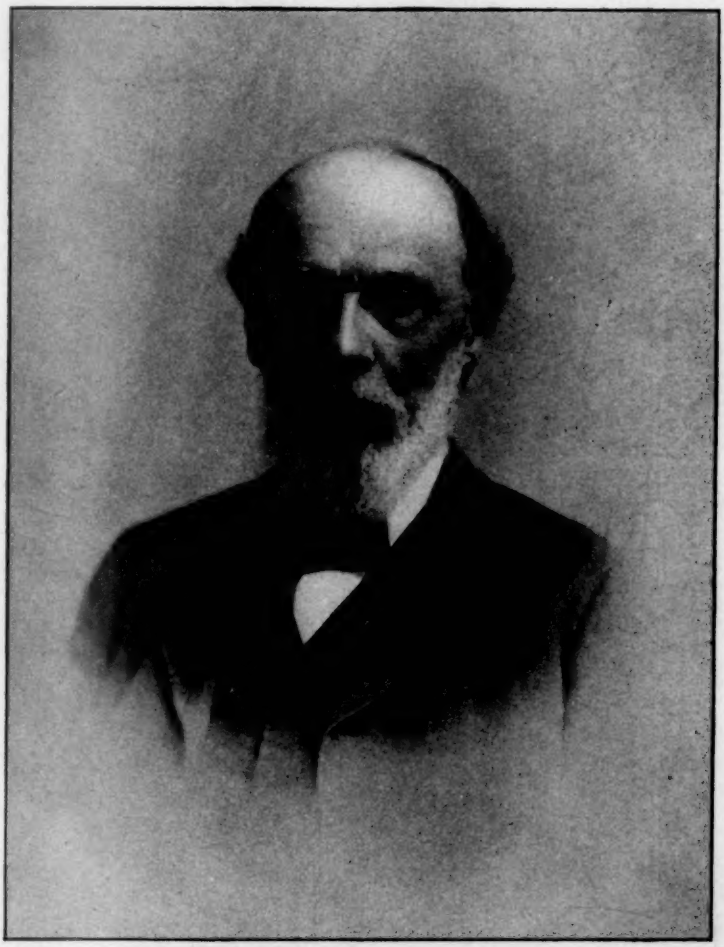
DR. HIMES:—There is one point not fully brought out in these statements in connection with the kromskop; that is the reproduction not simply of color, but of that often equally characteristic but less definable appearance of luster.

IN MEMORIAM.

WILLIAM PENN TATHAM.

William Penn Tatham, who died on August 5, 1899, while temporarily sojourning at Atlantic City, was the last survivor of five notable brothers, George N., Henry B., Benjamin, Charles B. and the subject of this memoir, who was born near Frankford, Philadelphia, in the year 1820. In 1840, the brothers formed a partnership for the purpose of manufacturing lead pipe and sheet lead, and located their establishment on Prune (now Locust) Street below Sixth Street. Their business soon grew to be of such importance as to require enlarged accommodations, which were obtained on Delaware Avenue below South Street, whereby greater facilities were acquired to meet the increased demand for the specialties they manufactured. Later, the works were removed to the building on Fifth Street above Locust, which had been especially designed for their purposes by William P. Tatham.

More machinery, of a heavier and better character, was installed, and its operation and maintenance were managed by the junior member of the firm; a duty for which he was well qualified by his aptitude for mechanics. The most important feature of their business was the introduction into this country of solidly-drawn lead pipe, and the consequent rejection of the method then in vogue, known as the "draw-bench," in which the longitudinal edges of lead strips of limited lengths were brought together and compressed into close contact, and the lips soldered to each other, and then rounded up by a die—a slow, laborious process. In the improved process, the pipe was solidly drawn



WILLIAM PENN TATHAM.

President of the Franklin Institute, 1879–1885.

or forced by hydrostatic pressure through annular dies, which were supported in the bottom of a receptacle for melted lead. When a charge of hot metal became reduced in temperature until upon the point of solidifying, it was ejected, forcibly and continuously, through the die, in unlimited lengths of uniform diameter and without seams. This effected a material gain in time, in durability of the product, and in the quantity of stock required to produce pipe of a given capacity.

Mr. Tatham devised an improvement in the preparation of ingots or slabs, intended for rolling into sheets. These were cast in open moulds, which, on being filled with hot metal, sometimes ruptured or became distorted, and delivered the content when cooled with its edges or sides in uneven thicknesses. This disadvantage was overcome by a judicious construction of the mould in wrought iron, which retained its shape and durability. Many other devices used in the works were originated by him, and which, though seemingly unimportant in themselves, were, in the aggregate, advantageous, and added materially to the facilities of the manufactory.

Mr. Tatham traveled extensively in Spain and in other parts of Europe, also in Egypt, up the Nile; then through England, where he made many friends. On his return home, in 1850, he became a member of the Franklin Institute; in 1870 he was elected a member of the Board of Managers, and in 1879 was elected to the presidency of the Institute, and held that position until the end of 1885. He was then re-elected a member of the Board of Managers, and in 1887 was elected one of the Vice-Presidents, and continued in that office until failing health caused his retirement in 1897. During his long connection with the Franklin Institute he was constant in his devotion to the advancement of its objects, and identified himself with all its important transactions. His intimate and harmonious associations with men prominent in business affairs and in the arts and sciences enabled him to enlist their sympathy and aid in his efforts to promote the purposes of the Institute.

For fifteen years Mr. Tatham held the congenial position of chairman of the Committee on Library. His knowledge of books on general subjects of interest and on the exact sciences enabled him to make selections from new contributions to science that seemed worthy of a place in the library, and to him it was a labor of love so to enrich it with works of reference as to maintain a high standard of excellence. Among these were the completed parts of the British and French reports on patents, obtained by favor through friends residing in those countries. These publications are rare and invaluable for reference, as is evinced by their constant use not only by the members of the Franklin Institute, but also by the legal fraternity and the general public interested in inventions.

Mr. Tatham was chairman of the Committee on Exhibitions in 1874, on the occurrence of the semi-centennial anniversary of the foundation of the Franklin Institute, when the Board of Managers resolved to commemorate the event by holding an exhibition of American manufactures. The time was auspicious. The custom of the Franklin Institute of holding annual exhibitions had been departed from chiefly for the reason that there was in existence no building suited to the purpose. During the preceding sixteen years no exhibition had been held. As the initial step, Mr. Tatham was fortunate in obtaining the consent of the Pennsylvania Railroad Company to use their freight depot at Thirteenth and Market Streets, then about to be abandoned for the more convenient location at Thirty-second and Market Streets, and he at once began the needed preliminary alterations and additions, and by his unflagging energy the building was speedily put into good order, and well adapted to its intended use. For the first time in its history the Franklin Institute had ample quarters, deserving of its many displays of American manufactures. The wisdom shown in the choice of location and the promptness in securing it were admirable. The opening was happily ushered in and the broad aisles were constantly thronged with visitors from far and near, examining the greatest and most valuable collection of American manufactures that the Franklin Institute had ever secured.

The result proved gratifying to all—visitors and exhibitors—and, incidentally, also to the treasury of the Franklin Institute. The administrative ability of Mr. Tatham and his constant general supervision and attention to details, combined with his success in enlisting the willing aid of many able coadjutors, made the result highly satisfactory. In many of the previous exhibitions by the Franklin Institute the expenditures exceeded the receipts; but in this case the treasury was replenished by an unprecedented profit of over $50,000, a timely addition, which for some time relieved the Institute from the embarrassment of an insufficient income.

In the autumn of 1884, during the presidency of Mr. Tatham, the Franklin Institute decided to hold an exhibition devoted to the electric arts. Again, by his influence, Mr. Tatham secured the aid of the Pennsylvania Railroad Company in furtherance of the object, by obtaining without charge the use of the station building at Thirty-second and Market Streets and of the vacant lot adjoining it on the west side. Upon these, special buildings were erected under his direction by an active committee of the Institute, and, when completed, and the exhibits installed, it was announced to be opened to the public by introductory remarks by the President. Of this exhibition, it has been said that "Measured by its results in stimulating the progress of electrical arts in the United States, it is acknowledged by all who are engaged in the electrical industries to have been by far the most important of its kind ever undertaken."

Mr. Tatham, in 1881, began to put into shape the result of much thought expended by him on the possibility of constructing an accurate transmitting dynamometer, that is to say, the production of a machine for measuring power, which, being placed between the source of power and the machine to be operated, could be relied upon to weigh the power required to operate the driven machine apart from the frictional resistance in the dynamometer itself. The Proney brake, considered by him the most correct method of determining the power of a steam engine or a water-

wheel within the limits of the power of such a brake, does so by absorbing all the power that is given off. Dynamometers of the Morin type, which are next in accuracy, are limited in application, while many existing transmitting dynamometers include the friction of the instrument in the power indicated. The main idea of Mr. Tatham was founded on a fact not generally considered in belt transmission, that the journal friction due to the weight of the belt or the tension of the belt is constant whether no power is being transmitted by the belt, or whether the full power of the belt is being transmitted from one shaft to another. Thus a belt, transmitting power from one shaft to another, is capable of transmitting power only to the extent of the adhesion of the belt surface to the pulley surface, due to the ultimate strength of the belt and its pressure on the pulley, incident to the weight or tightness of the belt within the limit of elasticity. The dominant idea in Mr. Tatham's mind was so to arrange a belt operating in and through a weighing machine that all strains shall be balanced, the only one actual weight being the amount of force or strain that is being transmitted by the tight side of the belt on the dynamometer. The various stages through which this machine passed can be found described in the Franklin Institute *Journal*, beginning with the paper on an "Improved Dynamometer," read before the Franklin Institute, November, 1881, published in volume CXII, No. 5. A second paper on the same subject will be found in volume CXIV, December 6, 1882, in which the ideas expressed in the first paper were advanced, and the machine presented to the Institute is described in detail, with valuable notes as to the results obtained and the mode of calibrating the instrument. On page 449, volume CXX, July to December, 1885, is a description of the improved dynamometer on the same principle, constructed in 1884 for the Franklin Institute and used by the Committee of Judges at the Electrical Exhibition, June, 1884. This instrument was capable of measuring 100 horsepower, and was used to determine the mechanical equivalent of heat on an enormous scale. The water churn was a cylinder 3 feet in diameter and 3 feet long, holding 1,223

pounds of water. The result of the experiment was that the mechanical equivalent of 1° C. is 1,391·05 foot-pounds, or the mechanical equivalent of 1° F., 772·81 foot-pounds. Professor Rowland's figures are higher. In Mr. Tatham's experiment, after the exit water had been brought to a uniform temperature, the experiment proper began and continued two and one-half hours, during which over 5 tons of water passed through the churn and was raised about 15·5° C. by the continued exertion of 46 horse-power. This machine is now deposited with the University of Pennsylvania, and is used to great advantage in the Engineering Department, under the direction of Prof. H. W. Spangler, Sc.D.

Mr. Tatham was largely instrumental in the organization of the Pennsylvania State Weather Service in 1887, in connection with the U. S. Weather Bureau, which lent its active coöperation to that end. He acted as the chairman of the Committee on Meteorology during the entire period in which the Institute conducted this work, and until the transfer of the Weather Bureau work to the newly-created Department of Agriculture removed the direction of the service from the control of the committee. During this entire period, covering some eight years, Mr. Tatham was indefatigable in his zeal and industry in promoting the efficiency of this committee's work, giving to it the same thoughtful attention that he was accustomed to bestow upon every responsibility which he assumed in his relations with the Franklin Institute. Every dollar of the expenditure of the appropriation made by the State Legislature to support this work received his critical personal supervision, and the publication of the Monthly Bulletins of the service in which he manifested the greatest interest received his watchful and solicitous attention.

Among the papers that he contributed to the Franklin Institute it may be noted that as chairman he was the author of a majority report of the committee on the "Enforced Adoption of the Metric System," in place of our present system of metrology. This report was adverse to its adoption, and is worthy of note as a full yet concise history of the

subject, and a valuable contribution to its literature. In its action thereon the Institute committed itself against the enforced adoption of the metric system, but approved the legalized use of it in whatever case or under whatever circumstances it should prove most useful to those who elected to employ it.

Mr. Tatham was elected a member of the American Philosophical Society in April, 1875; he was promptly elected as a Councillor, and, in 1897, was made chairman of the Committee on Finance, and served as Treasurer *pro tem.* upon the decease of the Treasurer, Mr. J. Sergeant Price. He was also a member of the committee appointed to devise a plan for increasing the facilities of the society by enlarging the space to be devoted to the display of its books.

During Mr. Tatham's term as President of the Franklin Institute the dress sword, which was worn by Dr. Franklin upon state occasions, was devised by one of his descendants, Mr. R. Meade Bache, who was then in possession of that historic relic, to the President of the Franklin Institute. This sword had been entrusted to the care of the Historical Society until such time as the Franklin Institute could provide a safe depository for it. This interesting relic is now in the custody of the Institute.*

In his youth Mr. Tatham was intended for the legal profession, but his natural inclination urged him to follow the more congenial pursuit of mechanics. His long life-work is evidence of the fitness of his choice. He was a man of sound judgment and firm convictions, prompt and faithful in his attention to the requirements of his official duties, and was not excelled by any in his strong interest in all that appertained to the welfare of the Franklin Institute and the sustainment of its reputation.

Mr. Tatham married, in 1867, Katherine K. Biddle, daughter of James Crowell Biddle and Sarah Caldwell Keppele, who survives him.

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* The Franklin sword has inscribed upon its sheath the following memoranda: Benjamin Franklin, 1755; B. F. Bache, 1790; R. Carr, 1797; W. Duane, 1859; H. Bache, 1860; R. Meade Bache, Wm. P. Tatham, Franklin Institute.

NOTES AND COMMENTS.

A NATIONAL PARK IN THE EAST.

The creation of a great national forestry and game reserve in northern Minnesota, embracing 7,000,000 acres around the headwaters of the Mississippi River, with many lakes of rare beauty, well stocked with fish, is being actively advocated in Congress by prominent citizens of Chicago and Minnesota. The promoters of the plan are not likely to experience much difficulty in interesting Congress. The game and the virgin forests of the United States are disappearing so rapidly, that it is exceedingly important that measures be taken, before it is too late, to save some of the great wooded areas of the continent.

It is one of the marked features of the legislative and popular indifference to their best interests common to those regions that such enterprises as this never originate in our Southern States. Yet there, it would seem, we have the most promising, most adaptable and most accessible regions for such purposes to be found anywhere within our national limits. Nearly all of the forestry reserves that have been established up to the present time are in the far Northwest; the chief of them, the Yellowstone National Park, is inaccessible to the great majority of the people. Nothing of national scope is to be found east of the Mississippi River.

Within about a day's travel of New York, Philadelphia, Baltimore, Washington and most of the Atlantic seaboard, and quite as accessible to Pittsburgh, Cincinnati, Louisville, Indianapolis and St. Louis, there are vast stretches of virgin forests—along the line of the Great Smoky Mountains, on the border between Tennessee and North Carolina—that are thoroughly suited to the purposes of a great game and forest preserve. Going up from the lowlands at Walhalla, S. C., to the high plateau surrounding Highlands, N. C., a stage trip of about 30 miles, the late Professor Gray, the eminent botanist of Harvard, tells us that he encountered a greater number of species of indigenous trees than could be observed in a trip from Turkey to England, through Europe, or from the Atlantic coast to the Rocky Mountain plateau. The region surrounding that described by Professor Gray, especially to the west, with the headwaters of the Tennessee, the French Broad and the Savannah Rivers, all within a few miles of each other, with fertile valleys and mountain elevations of 5,000 feet or more, and a density of verdure unapproached elsewhere, is an ideal spot for a preserve, where every sort of North American animal or fish would thrive and where almost every tree or plant found within our borders from the Atlantic to the Pacific would grow uncared for. The land in this region is still purchasable "for a song," certainly at as little as or even less than that obtaining in the Northwest. The climate, while sufficiently severe in the winter to suit the more northern species of animal life, is never sufficiently so to kill great quantities of game, either by freezing or through lack of winter food, as is not uncommon in the Northwest woods.

Added to the climatic and the varied physical characteristics of this region,

which especially fit it for the purposes in view, there is no like region obtainable where the varied and picturesque scenery so admirably adds to the desirability of the location. While these headwaters are singularly devoid of lakes, there are ample streams running through deep valleys and gorges which render the production of artificial lakes and reservoirs a matter of detail and of slight expenditure. Cascades and even waterfalls of very considerable dimensions abound on every hand, vast stretches of virgin forests, with an evergreen undergrowth of laurel, kalmia, rhododendron, etc., afford ample shelter and browsing for the winter, while the steep mountain sides, largely covered with bowlders and rocky ledges, from every cranny of which dense vegetation springs forth, furnish safe homes for all varieties of our smaller mammals.

A park that would take in the region along the Smoky Mountains around Clingman's Dome, or the southern slopes around where North and South Carolina and Georgia meet, in the middle of the headwaters of the Savannah River, or where Tennessee, North Carolina and Georgia meet, would not be misplaced. The timber and mineral wealth of the regions mentioned are such that it can only be a question of a few decades when these mountain slopes will be denuded and when the people of the vast valleys that depend on these watersheds for their water supply will suffer from the blindness of a generation that could not foresee the otherwise inevitable and combine its prevention with the benefits of an enduring national park in the populous East.—*Scientific American.*

WASTE PRODUCTS.

In a recent paper, read before the Engineers' Club of Philadelphia, John Birkinbine presented many interesting facts relating to the utilization of waste products, one of which has special interest for tin-plate manufacturers. Mr. Birkinbine says: "The possibilities of utilizing waste in a single direction were suggested by a visit to a large button works in Connecticut, where I was informed that 90 tons of buttons had been made in one month. The material used to produce these buttons was the remnants of the sheets of tin plate from which the bottoms and caps of cans for blacking and other boxes had been cut. After the button blanks had been punched from this tin-plate the small triangles of metal connected by iron threads were compressed in a form under a drop-hammer, and subsequently shipped away to be made into sash weights."

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS.

At a time when information regarding our new possessions is so much in demand, the memorandum by George F. Becker, of the United States Geological Survey, on the mineral resources of the Philippine Islands, will prove of great interest and value. The pamphlet, which was printed at length in a recent issue of the *Scientific American Supplement*, covers all the main discoveries in the geology of the Philippines which are of economic interest. The data were obtained from various sources, including unpublished records in the Spanish Mining Bureau, mine reports by the late William Ashburner, verbal information obtained in Manila, and from various technical publications.

The valuable minerals, as far as present knowledge goes, are confined to about a score of the islands. Luzon heads the list with deposits of coal, gold, copper, lead, iron, sulphur, marble and kaolin, while coal and gold are the two minerals most commonly found in the other islands. The Philippine Islands' coal is a highly carbonized lignite, analogous to the Japanese coal and that of the State of Washington, but not to the Welsh or Pennsylvania coals. It is thought that the native coal might be made to supplant the English or Australian coal for most purposes. Petroleum is found in Cebú, where a concession has been granted, and there are evidences of natural gas, while oil and gas are reported on Panay.

Gold is found in a vast number of localities in the archipelago. It is generally detrital and found in watercourses or stream deposits now deserted by the currents. There are placer deposits, some of which are worked in a crude way by the natives, and some of the gravels are adapted to hydraulic mining. In one of the islands a gold quartz vein has been worked, which is 6 feet in thickness and has yielded from $6 to $7 to the ton.

Copper ores are reported from a great number of localities, northern Luzon containing a copper region of unquestionable value, where the ore has been smelted by the natives from time immemorial. Other of the deposits are described as veins of rich ore 23 feet in thickness.

A lead mine has been partially developed near the town of Cebú, on the island of that name, while at Torrijos, on Marnidugue, a metric ton of argentiferous galena is said to contain 96 grams of silver, 6 grams of gold, and 565·5 kilograms of lead.

Iron ore exists in abundance in Luzon, Caraballo, Cebú, Panay and probably in other islands. The finest deposits in Luzon are near Camachin, where wrought iron is produced and manufactured into plowshares. Charcoal pig might be produced to some advantage in this region, but the lignites of the archipelago are probably unsuitable for iron blast furnaces.

Of non-metallic substances, sulphur deposits abound in Luzon and other islands, while marble of fine quality occurs in the island of Romblon and in the provinces of Manila and Marong. There are concessions for mining kaolin in Laguna province, and the pearl fisheries in the Sulú archipelago are said to form an important source of wealth.

Taken altogether, the above statement, coming from an official source, establishes the fact that the Philippine Islands have a solid mineral as well as agricultural value. When the pacification of the islands is effected a promising field will be open in the exploitation of the actual extent and value of these resources.

ARTIFICIAL SILK.

The production of artificial silk has for some time past attracted the attention of experimenters in France, and we learn from the *Scientific American* that it has been used with success to replace natural silk in certain fabrics. The Count du Chardonnet, who claims to be the first to have successfully carried out the process, exhibited some fine specimens of artificial silk at the Paris Exposition of 1889. Since then he has perfected his system, and, at

the present time, a factory of considerable importance is in operation at Besançon, under the direction of M. Tricano. This factory is now capable of producing 150 kilograms of artificial silk per day.

Natural silk is largely made up of a body called "fibröin," together with other substances such as gelatin, albumen, wax, coloring matter, fatty and resinous matter, etc., the cellulose of the mulberry leaf being thus transformed by the silkworm. The nature of these transformations is, of course, unknown, and in order to produce a substance resembling silk, a method is adopted by which the cellulose furnished by cotton is used as a base. The cotton, having been transformed into nitro-cellulose, or guncotton, by treating it with nitric and sulphuric acids, this latter is dissolved in a mixture of ether and alcohol, and the resulting collodion is filtered under pressure.

In order to be successfully used for the production of artificial silk, it is found that the collodion must be allowed to "age" for a certain period of time, the reason of which has not been definitely settled; however, it is certain that the collodion, on being allowed to stand, undergoes certain modifications by which it is better fitted for the purpose. It is then run into cylinders, which have capillary holes in the bottom, and the collodion is forced out of these holes under a pressure of forty to fifty atmospheres. It comes out in the form of white cylindrical filaments; these are united to form threads, which are put up in skeins and all traces of alcohol or water which they may contain are removed. In this state, however, the threads are extremely inflammable, partaking of the nature of guncotton, and to remove this difficulty they must be "de-nitrated," that is to say, the cellulose must be brought back into its normal condition. This part of the process, which is indeed an essential one, involves considerable difficulty, and has been experimented upon for some time by M. du Chardonnet and others. However, a process has at last been arrived at which accomplishes this in a satisfactory manner. The details of this process have not as yet been made public; but it is certain that by this operation white silky threads are produced, which are not appreciably more inflammable than natural silk. The skeins which have been made up of these threads are then dyed by immersing them in a heated bath of basic aniline color.

PRESSED STEEL CARS.

Apropos to the paper of Mr. Loss on the "Pressing of Steel," just published in the *Journal*, the following editorial comments on the behavior of pressed steel cars in collision from the Philadelphia *Record*, will be of interest:

"The announcement which was made a few weeks ago that the Carnegie Company had contracted to supply 1,000 tons of steel a day for ten years to the Pressed Steel Car Company, of Pittsburgh, has aroused much public interest in the cars referred to, and the question has been asked more than once: 'What would be the effect of a collision or other mishap on a railroad train equipped with steel cars?' The Baltimore and Ohio Railroad, which has just passed through a long period of reorganization, was completely remodeled and modernized in its rolling stock equipment during the receivership, and when the property was finally turned over to the owners the company possessed

about 6,000, nearly new, pressed steel cars. The Master Car-builder of the Pittsburg and Western Railway (which is a branch of the Baltimore and Ohio) has had several of the pressed steel cars sent to his repair shops from the road after having been in accidents of various kinds, and his report on the condition of the cars after the roughest usage in collisions is, therefore, interesting and instructive. Among other things he says:

"'Steel car No. 4211 left the track known as our Negley stone track, which is about 10 to 15 feet higher at the point where car left track than our main line. Car went over the bank, landing on main track, and blocked the road. Our superintendent happened to be on board a passenger train which came up behind this trouble, and cleared the track by use of engine and chains. This car was under load of 100,000 pounds of crushed stone. The sides were crushed in about 18 inches, bending all the side stakes on each side of the car, and breaking four journal boxes, one brake shaft, two hand holds, one winding shaft bent, drop door attachments bent, brake levers and guides torn off, truck channel bent and brake beams torn off. The pressed steel diamond truck under this car was subjected to a great deal of rough usage in getting main track cleared, as it would be reasonably supposed that the body of car received some very rough handling to avoid delay to trains. I supposed that I would have to remove all the side stakes on account of their bent condition, but, fortunately, we made a good, first-class job by using hydraulic jacks and hammering on stakes until we got the side straightened. The material required amounted to $8.37; labor, $30.60; total, $38.97.'

"'I might also add, for your information, which is very important, that if a train of wooden cars had been subjected to the punishment to which car No. 4211 was subjected there would have been nothing left but the scrap. In this case this car was the only car damaged in the train, it being so solid, substantially built, etc., that all other cars behind it were protected. A wooden car would not have stood the punishment that car No. 4211 went through under such heavy load.'

"The statements in this report (which covers several different accidents) prove that the pressed steel car, apart from its enormous carrying capacity and consequent economy as compared with wooden cars, is also practically indestructible. Even a single car in a train acts as a sort of buffer to protect the other cars in case of accident. For these reasons we may expect to see a rapid increase in the number of steel cars in use on passenger trains as well as on freight trains. In point of fact, there is no apparent reason why the ordinary passenger cars and drawing-room cars should not be built of pressed steel. The probable reason that steel passenger cars have not yet been built is that the Pressed Steel Car Company has been in operation a very short time (about three years), and has had more orders for the construction of freight cars than it could possibly fill up to this time. Pressed steel is coming more and more into use every day as a structural material; for it has been found that with sufficiently powerful presses rolled steel sheets of considerable size and thickness can be readily pressed into any desired shape, and at a moderate cost where many duplicates of the same form are required.

"These pressed steel pieces have immense strength, and are much lighter than steel castings intended for similar purposes. The method of manufacture is simply an enlargement of the quick method of stamping sheet brass, tin or

other metal into shapes for fancy boxes, hardware novelties, bicycle parts and multifarious metal goods of small size. Car wheels have been made of pressed steel for some time past, and have given good service. The process of pressing steel seems to occupy a position midway between the rapid stamping of small or light articles from sheet metal and the slow forging by powerful hydraulic presses of red-hot ingots of steel into great guns, enormous shafts for ocean greyhounds and other similar heavy work. The process of pressing steel is, we believe, capable of development so as to cover a much wider field."

ANTIMONY IN BRASS.

In a paper read before the American Institute of Mining Engineers, Mr. E. S. Sperry has pointed out that the occurrence of cracks during the rolling of brass is due, in some cases at least, to the presence of impurities in the copper of the alloy. In certain investigations made by this author, he added to a brass composition made of 60 per cent. of Lake copper and 40 per cent. zinc, quantities of antimony varying from 0·01 per cent. up to 0·65 per cent., and tested the behavior of the alloys thus obtained in the rolling mill. He found that when the percentage of antimony reached as much as 0·02 per cent., the fracture of the rolled metal indicated its presence. W.

PROTECTIVE COATINGS FOR THE IMMERSED PORTIONS OF IRON VESSELS.

The advent of iron ships has been accompanied with a difficulty, which has not yet been met satisfactorily—the finding of a suitable protective coating for the immersed parts, to protect them from corrosion and the attachment of marine plants and animals. The latter is the more troublesome, and, especially in tropical waters, the rapid accumulation of marine growths of this nature, in the course of a few months fouls the bottom of iron ships to such an extent that the speed is reduced to one-half or even more. This, of course, materially reduces the efficiency of a vessel—especially of a naval vessel—and necessitates frequent docking for scraping and cleaning.

The old plan, generally employed with wooden vessels, was to sheath them with copper sheathing. In the case of iron vessels, however, this cannot be done without first applying wooden sheathing to which the copper can be attached, and this is a somewhat expensive operation, which, on this account, is only occasionally resorted to. Nevertheless, unless some efficient substitute for copper sheathing is not devised in the near future, this expensive method will have to be adopted.

Attempts have been made to coat the iron hulls of ships with copper electrically, by a process of electric plating on a huge scale, but those appear to be unsuccessful. Meantime, recourse has been had to the application of various paints and similar protective coatings, none of which, thus far, have proved entirely satisfactory.

The *Chemiker Zeitung* of recent date contains an instructive article on this subject, from which the following information is derived. The author

enumerates the following indispensable conditions for a protective coating for iron ships to realize the requirements of service: (1) The compositions should protect the ship's hull from corrosion; (2) they should form a smooth surface, so as to decrease the friction; (3) they should dry quickly, so that the cleansing of the submarine parts and the application of a double coating can be done in a single day. In the case of new steel vessels, the black scale on the plates must first be removed by the use of acid pickle before applying the coating, which otherwise will drop away with the scale and permit the exposed metal to rust.

The author describes several paint compositions that have been used for this purpose, and gives the preference to that proposed by Rahtjen. This process consists in employing as the vehicle a solution of shellac in spirit, to which is added some iron oxide and a small proportion of linseed oil to give it elasticity. This first or priming coat is intended to serve for insulating the iron hull, and is followed by a second one composed of the same materials with the addition of arsenic and quicksilver. The Rahtjen compositions are highly commended for their permanency, as the salt of the sea water has but little action on the shellac which constitutes the vehicle of the paints. The efficiency of the second coating as a preventive of marine growths is ascribed to the formation of mercuric chloride by the slow action of the sea water on the quicksilver contained in the composition and which acts as a poison upon the marine organisms. These paints have the further advantage that they dry quickly, so that several coats may be laid on in a single day.

The defects of the Rahtjen paints are that only a small quantity of mercury can be incorporated in the paint, as otherwise the shellac would be affected, and that the effectiveness of the paint decreases with time because of the slight solubility of the shellac.

Of the mineral poisons incorporated in these compositions, copper and mercury have been found most efficacious. Copper would be preferable on account of the cheapness, but has the objection that when the insulating or priming coat has become defective, its presence in considerable quantities in proximity to the iron hull is apt to cause rapid corrosion of the iron by galvanic action.

The author of the article above referred to gives some instructive information as to the manner in which the efficiency of such protective compositions is called into action. Thus, he explains, the purpose of the poisons in the paint is to kill the germs of the crustaceous animals, which only swim about freely during the first stages of their development, and in seeking a permanent place of growth attach themselves to the vessel's hull. While the ship is moving through the water the paint layer is being continually affected by friction, so that the sea water can enter into chemical action with the poisons of the paint, whereby there results the production of an antiseptic (germicide) compound on the surface which destroys the organisms which come in contact with it; and so long as the ship's motion is continued, fresh portions of the paint film are successively exposed with the same result. In time the antiseptic action of the paint film ceases by the exhaustion of the poisonous material, when its virtue as preventive of marine growths ceases, though the insulating coating may still protect the hull from corrosion.

Again, when the hull of the vessel is at rest, as when in harbor, the con-

tinuous formation on the surface of the paint layer of an antiseptic substance is arrested, being rapidly exhausted by the vast amount of animal life coming in contact with it, and not being renewed by frictional contact with the water, as when the ship is in motion. This is the explanation of the fact that a vessel in port (particularly in tropical waters) fouls much more rapidly than when at sea. It is observed, however, that the antiseptic agents which have thus become exhausted after a few weeks' detention of the vessel in port, again become effective after putting to sea, when the exhausted particles of the paint skin are removed by friction, exposing a new poison-saturated surface.

The whole subject of the proper protection of the hulls of iron vessels from rusting and marine growths is in a sort of transition stage, very much like that of finding an efficient substitute for wood on warships; for notwithstanding the many remedial agents that have been proposed, none of them has fully met all the requirements, and the problem still awaits its solution. W.

NON-INFLAMMABLE WOOD, OR A SUBSTITUTE THEREFOR.

The frightfully destructive character of modern naval warfare is rendered still more terrifying by the frequent firing of the inflammable woodwork by the shells that penetrate to the interior of the vessels, and there is an urgent demand for a non-inflammable wood or for some efficient non-inflammable substitute, by all the navies of the world. There is no dearth of processes for rendering wood non-inflammable, and some of them doubtless are possessed of merit, being well adapted for use in ordinary construction, where slow burning is practically all that is needed for reasonably good fire protection; but when subjected to the extremely severe conditions demanded on shipboard, none of these products have succeeded in withstanding the tests. The British Admiralty, some time ago, subjected a number of these processes to careful trial, and with the result stated above. A trial of this nature is said to have been made on the U. S. Cruiser "Brooklyn," which also proved unsatisfactory, the treated wood having been removed and replaced with untreated wood. The German naval authorities also have given the subject anxious attention, but thus far no satisfactory solution of the problem has been found.

The products that have thus far been employed seem to have been made in part by the processes in vogue for preserving timber, such as impregnation with iron, copper or zinc salts, and in part by impregnation with such well-known fireproofing compounds as tungstate of sodium, phosphate of ammonium and the like. For one reason or another, however, such methods of treatment, while answering for the service for which they were first intended, prove to be unsatisfactory for naval requirements.

It has been suggested to try the efficacy of substitutes for wood, but in this direction also the experiments that have been made have given equally unsatisfactory results.

Here would seem to be a promising field for the inventor. The conditions to be met by such a substitute are toughness, lightness, resistance to wear under foot, non-inflammability, non-conductivity for heat, and freedom from liability to splinter under shell fire.

At one period it was thought that wood might be largely dispensed with in the construction of warships, and this idea was carried out in the building of one of the large English battleships, but it was found to be quite impracticable to do away with wood or some similar non-conducting sheathing in the interior of such vessels, since the bare metal, almost always dripping with moisture in the interior, is likewise found to be extremely cold in winter, and unendurably hot in summer.

The German naval authorities seem to have reached the conclusion that the most practical course to pursue, at least until some satisfactory process for fireproofing, or an efficient substitute for wood has been devised, is to restrict the use of wood in the construction of their warships to the smallest possible amount. To what extent they have succeeded in doing this will appear from statements lately made by Herr Dietrich, Conductor-in Chief of the German Navy, which are abstracted from recent impressions of *Cassier's Magazine*. "Wooden deck planks are no longer laid; steel deckplating is covered with linoleum, sometimes over a layer of cork. In the crews' quarters the sides of the ships are not ceiled, in the officers' rooms the ceiling is made of steel sheets, lined with cork. For cabin bulkheads the steel is covered with thin woolen cloth, and with cork lining underneath, where it is desirable to deaden sound or to lower the temperature * * *. All wood is removed from the ammunition rooms save the racks for shells and powder charges. * * * For all ladders and steps steel is used * * *. Chart houses and captains' rooms are made entirely of steel and fitted out with non-combustible materials. Since all such changes will be a little exaggerated, it seemed to be advisable to abandon wood for the interior fittings, and especially for the furniture, and to resort to fireproof material which will not splinter. Many things were tried; furniture was made of steel and aluminum lined with cork and covered with linoleum or canvas, but it was not equal to wood furniture. Only the bedsteads are constructed of iron, steel or brass. The insignificant quantity of wood in the few pieces of furniture when ignited is not considered a dangerous source of smoke, which is confined to the rest of the outfit of the staterooms—the mattresses, blankets, clothing and books."

This seems to be carrying the exclusion of the dangerous element of interior woodwork on warships to the very lowest practicable limit, and, next to employing an efficient substitute for it, is doubtless the best practice. The difficulties in the way of devising such a substitute, although very great, are by no means insurmountable, and it would not be surprising, in view of the very general interest now being taken in everything pertaining to naval affairs, if an early solution of the problem were found. W.

REMARKABLE USES OF PEAT.

One of the most interesting and attractive exhibits at the Vienna Exposition of last year was a building containing the most diverse articles made from peat. Everything in the building, from the carpets on the floor to the curtains at the windows and the paper on the wall, had been made from peat. These were but representatives of what will undoubtedly soon become a great industry and give to the peat bogs of the world a value never before dreamed of.

Credit for the discovery of the possibilities of peat belongs chiefly to a Vienna gentleman, Herr Karl A. Zschörner. His investigations into its nature began some twelve years ago with a study by means of the microscope of what is called in Austria "torfstreu." This is the layer of moss which covers the surface of most peat bogs. It has hitherto, by those who have made use of the peat for fuel, been, at considerable expense, removed and thrown away. Herr Zschörner's examination showed that the plant remains which make up this layer abound in hollow spiral cells. These absorb water and other fluids with great avidity. While ordinary straw cannot absorb over four times its weight of fluids, this peat straw will absorb ten times its weight. The peat straw, moreover, possesses the antiseptic and disinfectant qualities of peat, qualities which have long been known, but of which little use has been made. Herr Zschörner accordingly hit upon the idea of drying the straw and using it as an absorbent in stables, breweries and various manufactories. For such purposes it proved most admirably adapted, and the demand for the product soon grew large. Having greater absorptive power than ordinary straw, the peat straw can be used much longer in any given place and yet will have proportionally greater manurial value. It gives a healthy, resilient footing also for animals. For packing of both perishable and breakable articles it is also better than ordinary straw, since it is more elastic and less easily penetrated by heat and cold. Another form of peat which was found to be a better absorbent for some places was the peat itself, dried and ground to a powder. This is especially adapted for use in earth closets and about sinks and drains, its absorbent power and disinfectant properties making it admirably adapted for these uses.

Herr Zschörner did not rest his investigations here. A further study of the peat itself showed that it was very largely made up of fibers. These fibers come from the remains of reeds and grasses, which, growing and dying in successive generations, form the peat. In their submergence the reeds and grasses suffered no anatomical change, but their physical and chemical character became entirely different. The organic substance of the plant became inorganic, so that nothing capable of fermentation or decay was left, while the fibrous structure remained intact. These fibers then were found to have unusual physical properties. They were found to be very durable, very elastic, to be non-conductors of heat and non-combustible.

If a fabric could be woven from them, it would be one possessing unique properties. To the toughness of linen it would add the warmth of wool, an absorbent power greater than that of cotton, and the indestructibility of asbestos. It must, however, be woven without the aid of oils or water, or much of its value would be lost.

After twelve years of experimenting, Herr Zschörner succeeded in making the peat fibers weavable. There is now, therefore, scarcely any textile article which cannot be made from peat. Coats, hats, carpets, rugs, ropes, matting and pillows are some of the articles which have been made, and have been found useful. What superiority these will prove to have in practice over fabrics made from other fibers, only time will tell. Some of them have, however, already been proved to be immensely superior to any other fabrics. This is especially true of the blankets and other coverings used for horses and cattle, for they greatly excel in warmth, absorbent power, cleanliness

and durability. The unspun fiber promises to be a valuable substitute for absorbent cotton, since it will not only absorb a much greater quantity of blood and other fluids than cotton, but it possesses powerful antiseptic properties as well. The coarser fiber, it is expected, will come into favor for use in upholstery work, its extraordinary elasticity making it most valuable for this purpose.

The latest achievement of the discoverer of the uses of peat has been the making of paper from its fiber. This has been carried to such an extent that paper of almost every variety of weight and quality can be made, while the toughness and durability of each is equal to that of paper from any kind of vegetable pulp. The above are but a few of the uses to which this remarkable fiber can be put, but they indicate possibilities which may yet rank peat bogs among the most valuable of the world's resources.—*Oliver C. Farrington, in the Scientific American.*

CALCIUM.

M. Moissan, of the University of Paris, who has been successful in the extraction of the rare metals in the electrolytic furnace, has recently undertaken, according to the *Scientific American*, a series of experiments with the metal calcium, which, although abundantly distributed in nature in the state of carbonate, sulphate, etc., has not, up to the present time, been prepared in any considerable quantity in the pure state. It will be remembered that at the commencement of the century Sir Humphry Davy was the first to establish the existence in lime of a metallic body, and, by decomposing it by an electric current in the presence of mercury, he obtained an amalgam of the metal calcium. Later on, in 1855, Matthiessen electrolyzed a mixture of chloride of calcium and chloride of strontium, and thus obtained small globules of calcium having a yellow color. A few years later Jobin prepared the metal by a purely chemical process, causing the metal sodium to react upon iodide of calcium in fusion contained in an iron crucible; however, the quantity of metal obtained was small, 300 grams of iodide giving but 6 to 8 grams of calcium globules. After other experiments, scarcely more advantageous, M. Moissan has been the first to obtain a relatively considerable weight of the metal. He employs two methods; in the first, which is purely chemical, he utilizes the property which calcium possesses of dissolving in liquid sodium at a dull red heat. In an iron crucible of 1 liter capacity are placed 600 grams of anhydrous iodide of calcium, together with 240 grams of sodium. The whole is heated to dull redness, at which temperature the sodium unites with the iodine of the iodide of calcium, and the calcium set free dissolves in liquid sodium, which is in excess. Upon cooling it crystallizes in the middle of the mass of sodium, and by proper separation one may obtain brilliant hexagonal crystals of pure calcium. The amount of the latter is equal to 50 per cent. of the theoretical weight contained in the iodide, and 40 grams have been obtained at a single operation.

The second process employed by M. Moissan consists in the electrolysis of iodide of calcium in fusion at a dull red heat. A cylinder of pure nickel is used for the negative electrode, and for the positive a rod of graphite. The

calcium thus prepared has been examined as to its physical and chemical properties. Among its physical properties may be mentioned the following: It may be melted in vacuo at a temperature of 760° C., and then appears as a brilliant liquid. After cooling, the metal is rather soft, and may be cut with a knife. It may be broken by striking it, and the fracture presents a crystalline structure. Its surface, when it has not been attacked by gases, is of a clear white color, approaching that of silver. Its density is 1·85.

As to its chemical properties, calcium when brought to redness unites with hydrogen, forming a crystalline hydride; it combines with chlorine at 400° C., and with bromine and iodine at a dull-red heat. In oxygen the metal, when raised to 300° C., gives a brilliant combustion. It decomposes water at the ordinary temperature, and also decomposes sulphurous acid gas with incandescence. When heated in carbonic acid gas, it becomes covered with a deposit of carbon. Calcium combines with sulphur at 400° C., and burns with incandescence in the vapor of phosphorus. It unites with carbon in the state of lampblack below redness, and produces calcium carbide. Calcium when cold does not unite with nitrogen, but when heated in that gas it absorbs it slowly, and the metal, at first brilliant, assumes a yellow color. This explains why the alloys of calcium, which up to this time were regarded as the pure metal, were all more or less yellow, this color being due to the nitride. The latter compound is obtained in transparent crystals of a yellow-brown color, melting at 1200° C.

THE RAPID DECLINE OF GEYSER ACTIVITY IN YELLOWSTONE PARK.

Prof. E. H. Barbour, of the University of Nebraska, in a recent address on the subject, affirms that, if the present apparent rate of decline continues, it seems likely that within a decade many of the scenes which attract us most will have disappeared. It was his privilege to visit the National Park on August 5, 1895, and again on August 5, 1899, and certainly the evidence of change during these short years seems startling. To the geologist the change is serious and impressive. It may be said in a general way that there is an apparent decline of geyser phenomena everywhere throughout the Park.

To be more specific, without entering into many details, it may be stated that around the splendid terraces at the Mammoth Hot Springs, buildings now stand where there was steaming water in 1885. Spots which we photographed in 1895, standing shoe soles in water, are now either dry or nearly so. Minerva Terrace, which was boiling and which presented a fine array of geyserite in 1895, is falling into decay. Large blocks of the "formation" are falling from the rims and sides of the basins. To the eye the amount of water which flows over Pulpit Terrace and Jupiter Terrace is noticeably less.

We should say not one-half what it was four years before. The lattice work, constructed for the purpose of spraying and incrusting curios, was changed to a new spot where water was still flowing. The narrow gauge, which may be called a fissure vent, though still showing life, is extinct as compared with conditions four years ago. Roaring Mountain is still steaming, though silent. In the Norris Geyser basin the most obvious change is

in the Black Growler, which formerly emitted volumes of steam from an oblique vent by the roadside. The steam jet is now divided and the volume of steam and its roar and display of energy greatly diminished. The Fountain Geyser, which was such a favorite that the Fountain Hotel was located at that spot, is now wholly extinct, and tourists are complaining because they must waste time stopping at this hotel. The Fountain has been replaced by a new but very inferior substitute, named the Dewey Geyser. Tourists do not care to wait to see it in eruption. The giant paint pots are now so contracted in size that one can walk over what was a short time ago boiling mud. The red half is extinct; the white half active, though reduced in area. In the Upper Basin there is evidence on all sides of activity, but with many changes since 1895. Then the Splendid Geyser was attracting attention. Now it is silent and considered extinct. It is replaced by the Daisy Geyser, an interesting but vastly inferior substitute. The Cascade Geyser, another favorite, because of the frequency of its eruptions (about every fifteen minutes), has dropped to an eruption interval of once every twenty-four hours.

The Grand Geyser, which used to erupt once a day, has been active but three or four times the past season, according to all accounts. The Beehive Geyser, active in 1895, is supposed to be wholly extinct. Old Faithful seems as fine as ever, but the interval of eruption is now about seventy-five or eighty minutes instead of once an hour. If it is possible to judge fairly of such matters, there seems to be increasing activity in the ebullition of the water in that greatest of geysers, the Excelsior, which leads to a feeble hope that it may possibly be rejuvenated yet once again. In this connection may be mentioned the apparent increase in the activity of the Mud Geyser, by the thumb. The mud, which in 1895 was thick, and thrown up in large masses but a few feet, is now thinned and ejected as far as the road, a distance probably not far from 200 feet. At first thought it seems like increased activity, yet it may possibly be accounted for on the ground that the mud is in a condition making more active ejectment possible. A great quantity of mud has been thrown out recently, as much as 8 to 10 feet thick, and the trunks and boughs of the neighboring pines are loaded and weighed down with mud. Trunks were noted where the coating of mud halfway up to top exceeded 6 inches. The front half of the crater is now built up symmetrically with the other side, making a very regular funnel-shaped crater about 100 feet across, and some 25 or 30 feet deep. Below, the mud is in a state of constant and active ebullition. Possibly this case may be construed as a case of increasing activity; however, on the whole it is only too obvious that there is a serious decline, as one can see by observation, and can learn by consultation with the drivers, guides, tourists and officers at the barracks. It was the testimony of all that the changes were much more rapid than is understood, and our closing admonition is, visit the National Park at once.

Franklin Institute.

(*Proceedings of the stated meeting held Wednesday, February 21, 1900.*)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, February 21, 1900.

President JOHN BIRKINBINE in the chair.

Present, 92 members and visitors.

Additions to membership since last report, 32.

Mr. Howard B. French was elected a member of the Board of Managers to fill the vacancy caused by the resignation of Dr. Herbert M. Howe.

The President announced the Standing Committees for the current year.

Mr. Frank Hart, of New York, presented a communication on "The Development of the Cotton Industry in the United States, with Especial Reference to the Influence of Machinery upon its Growth."

The special purpose of his address was to emphasize the great importance of modern methods of handling and baling cotton as compared with the old and wasteful methods which, until recently, were exclusively used. The round lap baling system, which is now rapidly coming into general use throughout the cotton-growing districts of the South, obviates practically all of the objections of foreign manufacturers, while, at the same time, it permits of enormous savings. Mr. Hart affirmed that, if universally used, it would result in a saving of $45,000,000 on a 10,000,000 bale crop.

Mr. William C. Henderson, who has only recently returned from an extensive tour through this region, followed with an address on "The Cape Nome Gold District of Alaska." In his conclusions he strongly discouraged the idea that immense fortunes are to be made by pioneering this district, affirming that all the valuable gold-bearing territory in the region has been claimed and staked and even reclaimed and restaked again and again, so that the prospects confronting new-comers are most unfavorable.

Adjourned.

WM. H. WAHL, *Secretary.*

COMMITTEE ON SCIENCE AND THE ARTS.

[*Abstract of proceedings of the stated meeting held Wednesday, February 7, 1900.*]

PROF. EDGAR MARBURG in the chair.

The following reports were adopted:

Braiding Machine.—Andrew V. Groupe, Philadelphia.

ABSTRACT.—This invention is the subject of letters-patent of the United States, issued to applicant, numbered and dated, respectively, 588,421, August 17, 1897. It relates to that class of braiding machines wherein two sets of bobbins revolve around a common center, but in opposite directions, and, by the aid of complementary devices, cause the threads that pay out from each

bobbin to pass over and under each other, forming a braided cord, or a platted covering for a cord or other cord material, such as laces, shade-cords, braided ropes, whips, etc. "The essential feature of this invention consists in the construction and arrangement of a sectional trackway for the carriers of one set of bobbins, and in the mechanism for actuating said carriers, whereby the threads of the other set of bobbins are directed in an easy course between the adjacent track-sections and over and under the same and the carriers thereon, in a manner to minimize the friction of the coöperating parts and to insure a practically uniform tension on the respective threads, thus increasing the speed of the machine, and, perforce, the quality and quantity of the material produced thereby."

The model examined by the investigators was capable of doing good work at three times the speed of the common braider.

The report concludes as follows:

"In the 'sectional trackway' of this invention, in combination with a sinuous slot, through which the traveling threads pass freely over and under the inner bobbins, is found the one hitherto missing, but very essential, device that was needed to make this type of braider mechanically successful;" and in recognition of this ingenious contribution to the art, the John Scott award is recommended. [*Sub-Committee*, H. R. Heyl, Chairman; Luther L. Cheney, J. Logan Fitts.]

Process for Face-Hardening Rails.—Charles H. Priestley, Wilmington, Del.

Horseless Carriages.—Job Albert Davis, Philadelphia.

These two reports were made advisory.

The following reports were considered:

Pneumatic System for Preventing the Bursting of Water Pipes by Freezing.—N. Monroe Hopkins, Washington, D. C.

Electrical Switch.—Paul Medary, Cynwyd, Pa.

Micro-Stereoscopic Camera.—John G. Baker, Philadelphia.

Portable Photometer.—Charles Deshler and Edwin J. McAllister, Newark, N. J.

Water Heater for Range Boilers.—Adam Heller, Baltimore, Md.

Rail Joint.—Harry Wellenoweth, Philadelphia. W.

SECTIONS.

CHEMICAL SECTION (Photographic and Microscopic Branch).—*Stated Meeting, Tuesday, February 6th.* Dr. Henry Leffmann in the chair.

The subject for discussion was "The Applications of Photography and Microscopy to Medico-Legal Work."

The theme was discussed by Prof. W. M. L. Coplin, Prof. Arthur W. Goodspeed and the Chairman. The subject was illustrated with the aid of the stereopticon, the microscope and an X-ray machine.

The Executive Committee reported, as the result of a conference with a committee of the parent section, that no objection was made to the proposition to reorganize the Branch as an independent section, whereupon a resolution was unanimously passed, addressed to the Committee on Sectional Ar-

rangements, requesting that the seventy-nine members constituting the present Photographic and Microscopic Branch of the Chemical Section be granted the privilege of organizing the Section of Photography and Microscopy. W.

Stated Meeting, Tuesday, February 20th. Vice-President Lyman F. Kebler in the chair. Present, twenty-eight members and visitors.

Mr. B. H. Morrison presented a communication on "The Chemistry of Paper," which was illustrated with numerous specimens of the raw materials, pulps made by the several methods in vogue, chemical substances employed in the art, and a series of lantern views and photographs illustrating the various branches of the manufacture.

Dr. Leffmann exhibited an exceedingly characteristic test for the presence of wood pulp in paper, and some extremely old books and newspapers to show the excellent state of preservation of the paper.

Mr. Henrick Anderson discussed with Mr. Morrison some of the technical details of the manufacture of wood pulp. W.

MINING AND METALLURGICAL SECTION.—*Special Meeting, Wednesday, January 31st.* President Joseph Richards in the chair.

Dr. David T. Day of Washington, D. C., made a communication on "The Modern Uses of Fullers' Earth." The speaker exhibited a number of samples of clays found in the United States, which closely approach in composition and in physical characteristics the typical English clay which gives the name to this variety. Dr. Day described the uses of the material, other than in the fulling process. The most interesting of these is for the refining of oils.

Mr. William Griffith, of Scranton, Pa., read a paper on "The Flushing of Culm into Anthracite Coal Mines," illustrated by numerous lantern views exhibiting the method employed. The speaker clearly explained the value of the process in preventing the caving in of the surface ground, and as a means of effectively disposing of the great accumulations of refuse. W.

Stated Meeting, Wednesday, February 14th. President Richards in the chair.

Prof. John Gifford, of Cornell University, gave an extemporaneous address on "Forestry in Europe and America," illustrated with numerous lantern views.

The speaker specially dwelt upon the great care and attention bestowed upon the forests and forest industries in Europe, especially in France and Germany, contrasting this with the extremely wasteful methods in vogue in nearly every portion of the United States. He believed that the subject was now beginning to receive enlightened attention, and that the forest and its industries would in time be intelligently cared for. W.

MECHANICAL AND ENGINEERING SECTION.—*Stated Meeting, Thursday, February 8th.* Dr. Wahl in the chair.

Mr. H. DeB. Parsons, of New York, read a paper on "Fire Hazards," illustrated with numerous lantern views.

The speaker pointed out the common defects of construction in office and factory buildings, which greatly increases their liability to destruction by fire. W.